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Layouts and Operating Criteria for Automation of Dairy Plants Manufacturing Cottage and Cream Cheeses and Cultured Milk and Cream

Marketing Research Report No. 879

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Layouts and Operating Criteria for Automation of Dairy Plants Manufacturing Cottage and Cream Cheeses and Cultured Milk and Cream

By

P. H. Tracy

Marketing Research Report No. 879

Agricultural Research Service

United States Department of Agriculture

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PREFACE

This is one of a series of six reports submitted by P. H. Tracy under a research contract with the Transportation and Facilities Research Division, Agricultural Research Service, U.S. Department of Agriculture. These reports were prepared for Department publication by T. F. Webb, investigations leader, Handling and Facilities Research Branch, Transportation and Facilities Research Division.

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Layouts and Operating Criteria for Automation of Dairy Plants Manufacturing Cottage and Cream Cheeses and Cultured Milk and Cream

By P. H. Tracy [1]

SUMMARY

Automated and highly mechanized operating methods and an improved layout can reduce costs substantially for dairy plants manufacturing cottage and cream cheeses and cultured milk and cream.

Labor costs in a plant handling 1,200,000 pounds of milk weekly would be about $123,500 less on an annual basis in an automated plant with an improved layout than in a nonautomated plant with a typical layout. The production per man-hour for the automated plant is estimated to be 1,304 pounds (152 gallons) and for a nonautomated plant 715 pounds (83 gallons). The estimated cost of the additional equipment required to make these savings possible is $255,000. If the annual costs of ownership and operation of this additional equipment are estimated as 20 percent of the initial cost, the net saving due to automation is $72,500.

Some reduction in cost brought about by automation occurs in all operating areas of the plant although the greatest reductions are in the packaging and cleaning operations.

A layout and an operational plan were developed for a plant handling 1,200,000 pounds of milk weekly of which 75 percent is used in the manufacture of small curd cottage cheese, 10 percent for cream cheese, 10 percent for cultured milk, and 5 percent for cultured cream. The layout shows arrangement of equipment and work and storage areas for the most efficient flow of products, containers, and supplies through the plant. Provision is made for future expansion to double the original production.

INTRODUCTION

The increased demand for cottage and cream cheeses and cultured milk and cream and the special skill and equipment needed to manufacture these items on a large scale has led to the establishment of plants specializing in their manufacture for the large city markets, where most of the dairy products are sold in retail stores. Smaller dairies also often buy these products from the larger, specialized plants.

Recently developed equipment suitable for mechanizing the processes involved in the manufacture of cottage and cream cheeses, cultured milk and cultured cream and the application of electronic devices for the automatic control of these processes are described in this publication.

The purpose of this study is to supply the dairy industry with information that will be helpful in (a) increasing the productivity of labor in the plants through improved layout and automated procedures, (b) improving quality by establishing more uniform and better controlled methods of operation, (c) improving working conditions by doing away with jobs ordinarily requiring difficult and tedious labor, and (d) estimating the benefits resulting from such layouts, equipment, and automated methods. Such information should be helpful in remodeling old plants, as well as in building new ones.

A plant handling 1,200,000 pounds of milk weekly is used to illustrate the operating criteria and layout requirements for automated and highly mechanized operations.

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[1] Dr. Tracy, formerly professor of dairy technology, Department of Food Technology, University of Illinois, conducted the research and prepared the report under a research contract with the U.S. Department of Agriculture.

The labor needed for performing the various functions necessary to operate the automated plant is described in detail so as to better explain how the system works and to compare the estimated labor costs with those of a nonautomated and less mechanized operation of the same size.

Since manufacturing operations based on biological processes must be known to understand the problems of the application of both mechanization and automation to these processes, detailed explanations are given for the various procedures.

For many years cheesemaking has been more of an art than a science, involving much hand labor and requiring only a limited amount of equipment. Since bacterial and enzyme action plays an important part in making cheese, the time involved to perform the various steps necessary is a variable depending upon the reaction time of the acids and enzymes needed to produce the curd. Since slight variations in the composition of the milk and the heat treatment given the milk also affect the curd behavior, standardized mechanized methods have been difficult to perfect for the manufacture of cottage cheese. The yield of the cheese, as well as the body, may be adversely affected by such factors as the size and shape of the cheese vat, the time and temperature of pasteurization of the milk, the agitation given the curd while cooking, washing, draining, cooling, and creaming, and the method of packaging.

ASSUMPTIONS REGARDING PLANT OPERATIONS

Although conditions vary in different sections of the country, in this study certain assumptions were necessary on operating conditions. They were as follows:

1. The plant will be large enough to handle 1,200,000 pounds of whole milk weekly.

2. The milk will be purchased from local producers, and deliveries will be made daily in tank trucks. The milk composition will be 4-percent fat and 8.9-percent milk solids-not-fat.

3. The plant will operate 5 days per week.

4. The approximate utilization of the milk will be as folows:

   a. 75 percent as small curd cottage cheese containing 5-percent fat (legal minimum is 4 percent).

   b. 10 percent as cream cheese.

   c. 10 percent as cultured milk (1-percent fat).

   d. 5 percent as cultured cream (18-percent fat).

   e. All surplus fat is to be separated as 40-percent cream for the ice cream manufacturers.

5. The items to be manufactured will be marketed in the following packages:

   a. *Cottage cheese:*
      30 percent in bulk—50-pound plastic bags in corrugated boxes
      35 percent in 12-ounce paper packages
      35 percent in 6-ounce paper packages

   b. *Cultured milk:*
      80 percent in quart paper containers
      20 percent in half-pint paper containers

   c. *Cream cheese:*
      50 percent in 3-ounce foil-wrapped packages
      50 percent in 8-ounce foil-wrapped packages

   d. *Cultured cream:*
      100 percent in 8-ounce paper tubs

   e. *40-percent cream:*
      100 percent in bulk-tank truck loads

6. Volume of milk receipts will be as follows:

   a. Weekly maximum—1,200,000 pounds
      Weekly minimum—800,000 pounds

   b. Daily maximum—171,450 pounds
      Daily minimum—114,290 pounds

   c. Milk receiving—7 days per week

7. Volume of milk processed daily (5-day week):

   Maximum—240,000 pounds
   Minimum—160,000 pounds

8. Scheduled days of processing—Monday, Tuesday, Thursday, Friday, and Saturday.

9. Average gross composition of milk received:

   a. 4-percent butterfat

b. 12.9-percent total solids

10. Product and production specifications:

a. Cheese yield—17.75 percent, plus or minus 0.25 percent, of total volume skim milk plus culture weight in cheese vats.

b. *Dressing mixture:*

15.0-percent butterfat
2.8-percent salt
26.0-percent total solids
0.25-percent stabilizer

c. *Ratio of dressing to dry curd:*

1 to 2

d. Creamed cottage cheese finished at 5-percent butterfat (Federal standard requires minimum of 4 percent).

e. Cream cheese preparation from basic mix of 18-percent butterfat.

f. *Assume separating yield as follows:*

90.17-percent skim milk—0.075-percent fat
9.83-percent cream—40-percent fat

g. Products are standardized with 40-percent cream and 4-percent whole milk when possible.

Plant losses will vary from 0.5 to 1.0 percent of the receipts in an operation of this type, but no attempt will be made to account specifically for them in an analysis of this problem.

After Saturday's production, 6,823 pounds of whole milk will be held over (table 1). Under

TABLE 1.—*Utilization of raw milk, skim milk, and cream according to products manufactured each day based upon maximum receipts*

Item	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Raw milk receipts	171,430	171,430	171,430	171,430	171,430	171,430	171,340
Whole milk:							
For culture	0	720	720	0	720	720	720
For standardization	0	36,983	26,675	0	36,983	36,983	26,675
For separation	0	176,224	244,870	0	183,100	176,224	244,870
Total	0	213,927	272,265	0	220,803	213,927	272,265
Raw milk holdover	171,430	128,933	28,098	199,528	150,155	107,658	6,823
Skim milk separated	0	158,900	220,800	0	165,102	158,902	220,800
Cream separated	0	17,324	24,070	0	17,998	17,324	24,070
Skim milk:							
To cheese vats	0	158,900	158,900	0	158,900	158,900	158,900
To culture	0	0	12,400	0	6,200	0	12,400
Curd produced	0	29,300	29,300	0	29,300	29,300	29,300
Cheese dressing:							
Whole milk	0	10,175	10,175	0	10,175	10,175	10,175
Cream	0	4,475	4,475	0	4,475	4,475	4,475
Total produced	0	14,650	14,650	0	14,650	14,650	14,650
Cultured milk:							
Skim milk	0	0	49,500	0	0	0	49,500
Whole milk	0	0	16,500	0	0	0	16,500
Total produced	0	0	66,000	0	0	0	66,000
Cultured cream:							
Whole milk	0	12,222	0	0	12,222	12,222	0
Cream	0	7,778	0	0	7,778	7,778	0
Total produced	0	20,000	0	0	20,000	20,000	0
Cream cheese:							
Whole milk	0	14,586	0	0	14,586	14,586	0
Cream	0	414	4,200	0	414	4,614	4,200
Total produced	0	0	6,000	0	0	6,000	6,000
Total cream used	0	12,667	8,675	0	12,667	16,867	8,675
Total surplus cream	0	4,657	15,395	0	5,331	457	15,395

actual plant conditions enough cultured milk, cultured cream, or cream cheese would be made to assure complete utilization of whole milk at the end of each week. Also, the assumed values are based on no plant loss or shrinkage. Under good operating conditions, the amount of milk loss in a week's time in this plant would equal about 6,823 pounds, which would represent a shrinkage of 0.57 percent.

Another factor important to actual plant flexibility is the market demand for the various products. For example, the plant cannot profitably manufacture more of a given product than it can sell, and demand for such items as cottage cheese is seasonal. Daily adjustments are necessary, therefore, in the items manufactured to balance demand and supply. If necessary, low-heat nonfat dry milk solids can be used along with the available skim milk to meet an unusually heavy and unexpected demand for cottage cheese. The same holds true for the cultured milk and other products manufactured. Since the plant will always have a supply of surplus cream, enough fat will always be available for the products needed. There may be times when skim milk will be in surplus and will need to be sold for condensing or drying.

Total weekly utilization of raw milk, skim milk, and cream according to products manufactured, based on receipts of 1,200,000 pounds:

	Pounds
Raw milk receipts	1,200,000
Whole milk used for—	
Mother culture	3,600
Standardization	164,299
Separation	1,025,286
Total whole milk used	1,193,185
Total skim milk separated	924.500
Total cream separated	100,786
Skim milk—	
To vats	794,500
To culture for cottage cheese	31,000
Curd produced	146,500
Cheese dressing:	
Whole milk used	50,875
Cream used	22,375
Dressing produced	73,250
Cultured milk:	
Skim milk used	99,000
Whole milk used	33,000
Total cultured milk produced	132,000
Cultured cream:	
Cream used	23,335
Whole milk used	36,665
Total cultured milk produced	60,000
Cream cheese:	
Whole milk used	43,758
Cream used	13,758
Total cream cheese produced	18,000
Surplus cream	41,235

SUGGESTED LAYOUT OF THE PLANT

The major components of the plant are a receiving area; raw milk storage and processing room; bulk culture room; packaging room; cold storage room and shipping dock; dry storage room and dock; refrigeration room, shop, and boiler room; plant superintendent's office; general offices; locker rooms; lunchroom; cottage cheese processing room; cottage cheese creaming area; laboratory; and processing room for cream cheese, cultured milk, and cultured cream. A separate building is provided for the garage for the plant's delivery trucks. The garage will include a wash station and space for storing tires.

Current trends in food plant layouts, where the land is reasonable in cost, are toward single-level construction. However, the proposed plant provides for a two-story building with the laboratory and cottage cheese creaming area at a split level between the two floors (fig. 1).

Some of the fundamental reasons for this arrangement are:

1. In the handling procedures for cottage cheese, it is desirable to minimize pumping curd and to rely more on gravity flow. Furthermore, it is also desirable to minimize the distance of moving the fragile curd before packaging. Cottage cheese, therefore, is manufactured on the second floor of the plant and then moved by gravity to the first floor for packaging.

yout for an automated dairy plant manufacturing cot-
m cheeses and cultured milk and cream.

ning and purifying unit for packaging
pended from ceiling in dry storage room
ning and purifying unit for transfer and
n room, located on roof
ensing unit for (72) 12 tons
lensing unit for (73) 15 tons
ndensing unit for (74) 2 tons
utensil racks
up tanks (two)
P clean-up tanks (two)
r for tank trucks, suspended from ceil-

stations for CIP system (two)
pumps (two)
e return pump

pump recirculator
heating and circulating pumps for HTST
wo)

lensing units for laboratory coldroom, 1

ouble stacking pallets
access panels (six)

90 Electric distribution panel
91 Boiler feed water system
92 Control panel (for receiving and processing whole milk–in lab.)
93 Control panel (for HTST recorder-controllers and indicators for raw and pasteurized product tanks)
94 Control panel (for controlling pressures and temperatures in cultured products vat)
95 Cheese wash water feed pump, 50,000 lb./hr.
96 Cheese wash water filter and treating unit
97 Office air-conditioning unit
98, 98A Unit heaters suspended from ceiling
99 Heating and ventilating unit for processing room, suspended from ceiling
100 Heating and ventilating units located on roof (two)
101 Hot water heater, 50 g.p.m. with 500-gal. storage tank
102 Centrifugal sanitary pump for moving preset skim milk to cottage cheese vats (26, 26A-G)
103 Cultured milk box former
104 Cultured milk box sealer
105 Workbench in shop
106 Surplus cream cold-wall storage tank, 3,000 gal.
107 Whey pump
108 Incinerator

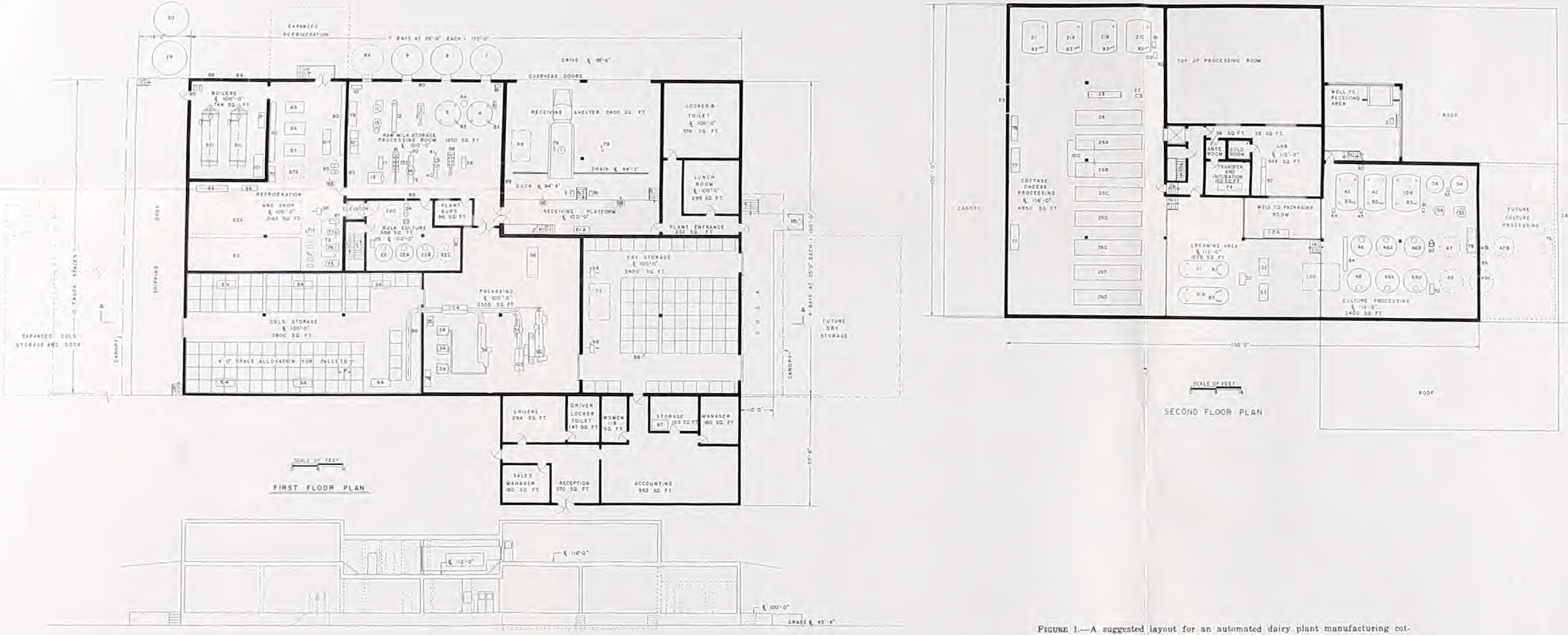

EXPANDED REFRIGERATION
7 BAYS AT 25'-0" EACH = 175'-0"
DRIVE ℄ 95'-6"
OVERHEAD DOORS
BOILERS ℄ 100'-0" 744 SQ. FT.
RAW MILK STORAGE PROCESSING ROOM ℄ 100'-0" 1850 SQ. FT.
RECEIVING SHELTER 2400 SQ. FT.
LOCKER & TOILET ℄ 100'-0" 576 SQ. FT.
LUNCH ROOM ℄ 100'-0" 299 SQ. FT.
DRAIN ℄ 94'-3"
DOCK ℄ 94'-9"
RECEIVING PLATFORM ℄ 100'-0"
PLANT ENTRANCE 232 SQ. FT.
REFRIGERATION AND SHOP ℄ 100'-0" 2163 SQ. FT.
ELEVATOR
PLANT SUPT. 96 SQ. FT.
BULK CULTURE 558 SQ. FT. ℄ 100'-0"
DRY STORAGE ℄ 100'-0" 2400 SQ. FT.
PACKAGING ℄ 100'-0" 2508 SQ. FT.
COLD STORAGE ℄ 100'-0" 2800 SQ. FT.
4'-0" SPACE ALLOCATION FOR PALLETS
DOCK
SHIPPING
CANOPY
EXPANDED COLD STORAGE AND DOCK
FUTURE DRY STORAGE
4 BAYS AT 25'-0" EACH = 100'-0"
DRIVERS 294 SQ. FT.
DRIVER LOCKER TOILET 147 SQ. FT.
WOMEN 118 SQ. FT.
STORAGE 160 SQ. FT.
MANAGER 160 SQ. FT.
SALES MANAGER 160 SQ. FT.
RECEPTION 370 SQ. FT.
ACCOUNTING 953 SQ. FT.
SCALE OF FEET
FIRST FLOOR PLAN
TOP OF PROCESSING ROOM
WELL TO RECEIVING AREA
ROOF
COTTAGE CHEESE PROCESSING ℄ 116'-0" 4850 SQ. FT.
ANTE ROOM
COLD ROOM
TRANSFER AND INCUBATION 150 SQ. FT.
LAB ℄ 112'-0" 549 SQ. FT.
WELL TO PACKAGING ROOM
CREAMING AREA ℄ 112'-0" 1030 SQ. FT.
CULTURE PROCESSING ℄ 116'-0" 2400 SQ. FT.
FUTURE CULTURE PROCESSING
CANOPY
50'-0"
SCALE OF FEET
SECOND FLOOR PLAN
℄ 112'-0"
℄ 116'-0"
℄ 100'-0"
GRADE ℄ 95'-6"
A-A

FIGURE 1.—A suggested layout for an automated dairy plant manufacturing cottage and cream cheeses and cultured milk and cream.

1 Tank truck, 2,000 gallons, in position to unload raw milk.
2 Raw milk receiving pump, 100,000 lb./hr.
3 Raw milk plate cooler, 100,000 lb./hr.
4 Weigh tank, 3,000 gallons
5 Weigh tank, 3,000 gallons
6 Raw milk transfer pump, 100,000 lb./hr.
7 Horizontal storage tank, 8,000 gal.
8 Horizontal storage tank, 8,000 gal.
9 Horizontal storage tank, 8,000 gal.
9A Future horizontal storage stank, 8,000 gal.
10 Measure flow pump for clarifier, preheater, separator, and HTST unit, 40,000 lb./hr.
11 Cold milk clarifier, 40,000 lb./hr.
12 Tubular preheater, 40,000 lb./hr.
13 Milk separator, 40,000 lb./hr.
14 Balance tank
15 Booster pump, 36,200 lb./hr.
16 HTST system for skim milk and cheese dressing, 36,200 lb./hr.
17 Measure flow positive displacement pump to move pasteurized skim milk to preset vats, 8,000–40,000 lb./hr.
18 Homogenizer, 1,200 gal./hr.
19 HTST holding tube, 16-sec., 36,200 lb./hr.
20 HTST flow-diversion valve
21, 21A-C Preset vats, 2,400 gal.
22, 22A, B Culture vats, 800 gal.
22C, D Future culture vats, 800 gal.
23 Calcium chloride mixing tank
24 Calcium chloride metering pump
25 Culture metering pump
26, 26A-G Cottage cheese vats, 1,200 gal.
27 Whey circulating pump, 25,000 lb./hr.
28 Tubular whey heater, 25,000 lb./hr.
29 Insulated cheese wash water storage tank, 15,000 gal.
30 Whey storage tank, 15,000 gal.
31, 31A Curd draining and creaming vats
32 Cottage cheese, lobe-type pump, 10,000 lb./hr.
33, 33A Curd and dressing blenders, 6,000 lb./hr.
34, 34A-B Cheese packaging machines, 25–100 cups/minute
35 Cottage cheese bulk carton filler
36 Automatic box former and caser, 240 cups/minute
37 Balance tank
38 HTST system for cream, 3,800 lb./hr.
39 Positive displacement timing pump, 3,800 lb./hr.
40 HTST holding tube, 16-sec., 3,800 lb./hr.
41 HTST flow-diversion valve
42 Cream cold-wall storage tank, 2,000 gal.
43 Cheese dressing cold-wall storage tank, 2,000 gal.
44 Cheese dressing feed pump, 10,000 lb./hr.
45 Cream pump, 20,000 lb./hr.
46, 46A, B Cultured cream vacuum pressure vats, 1,000 gal.
47, 47A, B Future cultured cream vacuum pressure vats, 1,000 gal.
48, 48A, B Cultured milk vacuum pressure vats, 2,000 gal.
49, 49A Future cultured milk vacuum pressure vats, 2,000 gal.
50 Paper bottle filler for cultured milk, 75 cartons/min.
51 Automatic caser, 75 cartons/min.
52 Positive displacement feed pump for curd concentrator, 8,300 lb./hr.
53 Curd concentrator, input 900 gal./hr.; curd output, 1,000 lb.
54, 54A Cream cheese processing kettles, 1,500 lb.
55 Homogenizer feed pump, 1,037 lb./hr.
56 Homogenizer, 125 gal./hr.
57 Pressure relief valve (not shown on layout)
58 Cream cheese packaging machine, 50 3-oz. or 35 8-oz./min.
59 Steam injector (not shown on layout)
60, 60A Boilers, 250 hp.
61 Three-tank automatic CIP unit
62 Ice builders, 62,000 lbs.
62A Future ice builders, 62,000 lbs.
63 Cheese wash water cooler, 15,600 lb./hr.
64, 64A-E Ceiling-hung room cooling units, 4 tons each
65 Ammonia compressor, 36 tons
66 Ammonia compressor, 61 tons
67 Ammonia compressor, 47 tons
67A Future ammonia compressor, 47 tons
68 Evaporative condensers, 75 tons (two on roof—not shown on layout)
68A Future evaporative condenser (on roof—not shown on layout)
69 Ammonia receiver, 20 in. by 20 ft.
70 Air compressor, 20 hp.
71 Sweetwater circulating pumps
71A Future sweetwater circulating pumps
72 Air-conditioning and purifying units for culture room and laboratory, suspended from ceiling in refrigeration room and shop
73 Air-conditioning and purifying unit for packaging room suspended from ceiling in dry storage room
74 Air-conditioning and purifying unit for transfer and incubation room, located on roof
75 Freon condensing unit for (72) 12 tons
76 Freon condensing unit for (73) 15 tons
76A Freon condensing unit for (74) 2 tons
77, 77A Cheese utensil racks
78 COP clean-up tanks (two)
78A Future COP clean-up tanks (two)
79, 79A Washer for tank trucks, suspended from ceiling
80 Connecting stations for CIP system (two)
81 CIP return pumps (two)
82 CIP portable return pump
83 Load cells
84 Funnel and pump recirculator
85 Hot water heating and circulating pumps for HTST system (two)
86 Conveyor
87 Freon condensing units for laboratory coldroom, 1 ton
88 Racks for double stacking pallets
89 Equipment access panels (six)
90 Electric distribution panel
91 Boiler feed water system
92 Control panel (for receiving and processing whole milk–in lab.)
93 Control panel (for HTST recorder-controllers and indicators for raw and pasteurized product tanks)
94 Control panel (for controlling pressures and temperatures in cultured products vat)
95 Cheese wash water feed pump, 50,000 lb./hr.
96 Cheese wash water filter and treating unit
97 Office air-conditioning unit
98, 98A Unit heaters suspended from ceiling
99 Heating and ventilating unit for processing room, suspended from ceiling
100 Heating and ventilating units located on roof (two)
101 Hot water heater, 50 g.p.m. with 500-gal. storage tank
102 Centrifugal sanitary pump for moving preset skim milk to cottage cheese vats (26, 26A-G)
103 Cultured milk box former
104 Cultured milk box sealer
105 Workbench in shop
106 Surplus cream cold-wall storage tank, 3,000 gal.
107 Whey pump
108 Incinerator

2. Control of all operations is centered in the laboratory. Locating the laboratory at a split level between the two floors allows all processing activity to be observed from one point, thus providing better control of the mechanized operations and maximum coordination of the plant labor.

Location of components by floor levels:

1. The milk receiving, processing and packaging facilities, the dry and cold storage rooms, shipping dock, the cold storage refrigeration system and boiler room, and the offices, lockers, lunchroom, and related rooms are located at the first floor level, which is 54 inches above ground level.
2. The laboratory is 12 feet above the first floor level.
3. The culture processing area is 4 feet above the laboratory floor level on the second floor.
4. The cottage cheese vats and preset tanks are on a level 4 feet above the draining and creaming vats on the second floor.
5. The cottage cheese blenders are suspended through the floor above the packaging room so that the top level is about 1 foot above the floor. This is designed to facilitate gravity draining of creamed curd to the packaging machine and to provide valve control easily accessible to the packaging crew at the bottom level of the blenders.
6. The shipping dock is at a level permitting plant-floor to truck-floor unloading by a forklift truck.

The layout shows the arrangement of the components in the plant, as well as the various items of equipment in each component. Each item is numbered and is referred to by number (in parentheses) in the discussion of the various components.

The part of the building that houses the processing operations and the receiving dock and shelter is rectangular and two stories high. It covers an area 100 feet by 176 feet, or 17,600 square feet. The single-story office, which extends to the front of the processing areas, is also rectangular and is 34 feet by 76 feet, covering an area of 2,584 square feet.

The dry storage receiving dock and the cold storage loading-out dock are on opposite sides of the building. The former is 10 feet by 25 feet and has an area of 250 square feet. The loading-out dock is 16 feet by 100 feet, an area of 1,600 square feet. The total ground area covered by the plant, offices, and two docks is 22,034 square feet.

No provisions are made for a basement, though the first floor is raised 54 inches above grade level for convenience in loading trucks. The use of two floors not only permits cheaper building construction but also provides for gravity flow of the finished cheese and cultured products into the fillers located on the first floor.

The arrangement of the various processing areas in this plant is such that there is a straight-line flow of materials. The plant layout was planned to provide for simplicity in automatic control of the various machines. In a plant where several different processes proceed by stages, the workers must diversify their operations. The processes should be so planned, therefore, that workers can quickly shift from one item of equipment to another so as to obtain maximum utilization of labor and to reduce downtime to a minimum. The straight-line operations in this plant and the compact arrangement of equipment achieve this purpose. This is accomplished without interference with the preplanned additions to the plant area when the volume of business is doubled, as shown by the proposed additions to the plant in the layout of the first floor.

The two storage rooms are designed for palletized storage and the handling of pallets with motorized lift trucks. The indicated areas for storage were calculated on the basis of 12–14 days' needs of dry storage and a peak day's need for cold storage. Ample aisle space is provided for movement of the pallets by the lift truck.

The various processing components of the plant are so arranged that not only will milk have a minimum amount of travel from the time it enters the plant until it leaves in finished form but also workers will have a minimum amount of movement in performing the various mechanized functions involved.

The milk receiving and storage operations are located to the rear of the plant adjacent to the pasteurizing and separating area. The skim milk and cream, being in liquid form, are easily pumped to the second floor for processing into cheese and cultured products. From here they flow by gravity to the first floor, where the filling and boxing functions are performed.

The packaging area is located not only for convenient gravity flow of the various products into the fillers but directly adjacent to the source of stored paper containers and shipping boxes on one side and the refrigerated storage room on the other. Empty containers arrive at the dock adjacent to the dry storage room and, when filled, leave from the dock adjacent to the cold storage room, thus providing for a straight-line flow.

The shop, steam boilers, and refrigeration equipment are located in the area at the corner of the first floor adjacent to the cold storage room on one side and adjacent to the milk and cream processing area on the other side. This area is also located below the product processing area on the second floor, thus providing for a short distance of travel for the steam, hot water, chilled water, and refrigeration gas and liquid.

For convenience in supervising plant operations, the plant superintendent's office is located on the first floor near the center of operations with quick access to the main office and close to the stairway leading to the second floor. Glass walls in this office and the intraplant communication system further facilitate the duties of the superintendent.

Many of the controls for processing are centered in the control panel located in the laboratory on the split-level floor between the two main floors of the plant, since the laboratory personnel is largely responsible for the supervision of most of the operations in the plant. The other two control panels are located in processing areas, one on the first floor and the other on the second at points in close proximity to the machines they regulate.

The two cleaned-in-place (CIP) units and their control panels are located on the first floor. One unit is on the dock convenient to the tank trucks and milk weighing and storage tanks; the other unit is located in the processing room where it can be conveniently operated by the workers involved in the cleaning of the processing equipment on both floors.

The two docks, one for incoming items and the other for outgoing products, are on opposite sides of the building, thus providing for a convenient and short flow of empty cartons and shipping boxes from dry storage to the filling machines, thence into cold storage and finally to the loading-out dock. Operations at the three docks do not interfere with each other, since all three are on different sides of the building.

The location of the main offices at the front of the building provides for a certain degree of desired isolation of office functions from plant operations. Provision is made for access from one to the other, but traffic can be limited to top personnel. The drivers need not go through the plant to check in at the office, since there is an outside entrance to the drivers' room at one end of the main office adjacent to the loading-out dock. The arrangement of the offices in the main office area makes for convenience in handling the usual office routines that involve the sales department, the clerical help, the receptionist, and the manager.

All plant workers enter and leave the plant through an entrance adjacent to the plant lunchroom. In this way, traffic is minimal through the plant proper, which is important from the standpoint of bacteriophage contamination.

The garage for washing, servicing, and storing the semitrailer delivery trucks is located at a point adjacent to the side road but far enough from the plant not to interfere with the flow of traffic around the loading docks.

Components of the Facility

Receiving Area

An area large enough to unload four 2,000-gallon tank trucks and to wash them at one time is provided.

The receiving platform is 12 feet wide and 50 feet long. In front of the platform is an 8-foot-wide platform. It is 5 feet 3 inches lower than the receiving platform. The area provided for unloading trucks is 50 feet wide and 30 feet long and contains 1,500 square feet. The floor of the approach to the dock is sloped from the front to the dock platform with a drop of one-half inch per foot. A drain is provided at the rear where the floor is 6 inches below the platform. Steps connect these three levels of floors.

A receiving pump (2) discharges milk from the tank truck at the rate of 100,000 pounds per hour. A tank truck (1) can be emptied in about 6 minutes. A two-tank CIP system (61A) on the platform is used for cleaning the trucks after they are emptied and also for the weighing and storage tanks (4, 5) for raw milk (located in the milk storage and processing room next to the receiving area). Two truck tank washing assemblies (79, 79A) are mounted on a hoist and monorail to facilitate moving them into and out of the tank manhole and from tank to tank. A hose connects the CIP return pump (81) with the tank trucks. The truck tanks have built-in spray ball cleaning devices.

Power-operated overhead doors make it possible to close the truck unloading area to the outside quickly and easily.

A removable panel (89) at the side of the platform next to the milk storage and processing room is provided for moving large pieces of machinery into and out of the plant. There are two stairways from this area, one leading down to the ground level and the other to the second floor of the plant. Two unit heaters (98,98A) and a heating and ventilating unit (99) for the processing room are suspended from the ceiling in the receiving area.

Processing Room

The raw milk storage and processing room contains 1,850 square feet. It is located next to the receiving area. The necessary facilities to cool and store the incoming raw milk are located here as well as the facilities to clarify, separate, and pasteurize the raw milk and cream. Included here is the raw milk plate cooler (3), which has a capacity of 100,000 pounds per hour, and two 3,000-gallon weigh tanks (4, 5) with agitators. They are adapted for cleaning in place and are mounted on load cells (83).

A load cell is an electronic weighing device, which is attached to the leg sockets of the tank. From two to four cells are used per piece of equipment, depending on the accuracy in weighing required. With two cells an accuracy of 0.25 percent can be obtained and with four cells an accuracy of 0.10 percent is possible. The load cells support the tank weight. As the milk product enters or leaves the tank, the weight difference is measured electronically, and the voltage is sent to the calibrated indicator, where the weight is shown and recorded. Other items of equipment in the plant that have load cells are the preset vats (21), the curd draining and creaming vat (31), the cream storage tank (42), the cream cheese processing kettles (54), and the surplus cream storage tank (106).

Also located in this area are the raw milk transfer pump (6), 100,000 pounds per hour, and three 8,000-gallon horizontal storage tanks (7, 8, 9), which are bulkheaded into the outside wall of the room to save floorspace. Space is provided for a future tank (9A) of the same size. These tanks are equipped with agitators and are adapted for cleaning in place.

For removing insoluble sediment and body cells from the milk, a cold milk clarifier (11) with a capacity of 40,000 pounds per hour is installed in the line ahead of the milk separator (13), which also has a capacity of 40,000 pounds per hour. Of equal capacity is the tubular preheater (12), which warms the milk from 36° to 90° F. before it enters the separator. A measure flow pump (10) forces the milk through the system.

For pasteurizing skim milk and cottage cheese dressing, HTST (High-Temperature Short-Time) pasteurizing unit (16) with flow-diversion valve (20) and 16-second holding tube (19) is provided. It is designed to process 36,200 pounds per hour and contains heating, regenerative, and cooling sections. The incoming raw skim milk enters at 90° F. and the outgoing pasteurized skim milk is cooled to 90°.

Included with this system is a balance tank (14), an 8,000- to 40,000-pounds-per-hour measure flow pump (17), and a 36,200-pounds per-hour booster pump (15). For processing the cream dressing, a 1,200-gallon-per-hour homogenizer (18) is provided.

The HTST unit (38) is for processing 40-percent cream at the rate of 3,800 pounds per hour. It contains a heating, regenerative, and sweetwater cooling section designed to heat the

90° F. raw cream to 170°, pass it through the 16-second holding tube (40), back through the regenerative section of the heater and then into the cooling section where it is further cooled to a final temperature of 40°. A flow-diversion valve (41), a balance tank (37), and a 3,800-pound-per-hour positive displacement pump (39) complete this unit.

Located in this room also are a 3-tank CIP system (61) for use on both hot and cold milk flow surfaces; a connecting station (80) for CIP system 61A; a CIP return pump (81); a COP (clean-out-of-place) cleanup tank (78) for cleaning items such as separator parts that cannot be cleaned until the machine is disassembled.

A funnel and pump recirculator (84) are placed near the weigh tanks (4, 5) for use in adding nonfat dry milk solids to the milk when needed.

Control panel (93) is located in this room (fig. 2). It provides panels to show which raw tank is being emptied and which tank is being filled with pasteurized product. It also provides controls for tank agitators and HTST recorder-controllers for pasteurizing the various products.

Cottage Cheese Processing Area

This room, located on the second floor, contains 4,850 square feet. At one end of this room are located the four 2,400-gallon preset vats (21) equipped with agitators; 2-inch air-operated outlet valves; load cells (83); CIP return pump (81); CIP connecting station (80); centrifugal pump (102) for moving preset skim milk to the cottage cheese vats; and heating and ventilating units (100) located on the roof. There are eight 1,200-gallon cottage cheese vats (26); they are 20 feet 8⅛ inches long, 63$^{15}/_{16}$ inches wide, and 34 inches high with a slope to the front. There is a 4-inch outlet valve for rapid drainage. Each vat is supported by 10 legs. There is no outside jacket or water circulation assembly, since the curd is cooked by circulation of the hot whey.

Adjacent to these vats is the whey circulating pump (27), 25,000-pound-per-hour, with tubular whey heater (28), also 25,000 pounds per hour. There is one COP cleanup tank (78).

Cheese utensils should be kept off the floor and should be handled carefully to prevent damaging them. Therefore, two stainless steel racks (77) are provided to house the stainless steel cheese paddles, cheese knives, strainers, pails, ladles, thermometers, and other small items of equipment needed. The overall length of the rack is 79 inches and the width is 30½ inches. It is 65½ inches high and is mounted on four swivel casters.

Since dumping cheese whey into a sewer or into an open stream is illegal in most communities, a whey storage tank (30) is provided on the ground level near the boiler room. The whey is moved by pump (27) from the cheese vats to this tank, where it is hauled away by farmers who use it for feeding livestock.

Cottage Cheese Creaming Area

At a level 4 feet below that of the cheesemaking room is the area where the equipment for adding the cream dressing to the curd and for mixing the dressing and curd is located. The curd and final rinse water flow by gravity to the draining and creaming vats (31). There are two of these vats 13 feet long, 64 inches wide, and 40$^{5}/_{16}$ inches high. The ends are rounded. An agitator and hydraulic lift are provided for rapid draining of the wash water. Each vat is mounted on load cells (83) so that the curd weight can be determined for calculating yield and also for determining the amount of cream dressing needed. Each vat has a capacity of 5,500 pounds of cheese curd and dressing.

To move the curd and dressing to the blender (33) a lobe-type pump (32) is located adjacent to the draining and creaming vats. This pump is so constructed that there is little breakdown of the curd when it is moved through the short sanitary lines into the blender. The pump uses a rotor having a slot in which slides an impeller guided by the interior of the pump body, which has an elliptical cavity and is provided with an inlet and outlet. The motor drives the rotor and impeller.

When the pump is started, there is an increase in cavity volume behind the pump impeller as it revolves within the body of the pump, thus creating a partial vacuum. In this way atmospheric pressure is all that is needed to force the slurry of curd and cream into the pump body through the suction port which fills the enlarging cavity created by the forward movement of the impeller. When the impeller passes the inlet port, the outlet port is simultaneously opened as the impeller slides on end in the rotor and pushes the product forward toward the discharge port. Handled in this way, the curd suffers little breakage.

The internal friction parts of the pump are made of different materials. The rotor is of

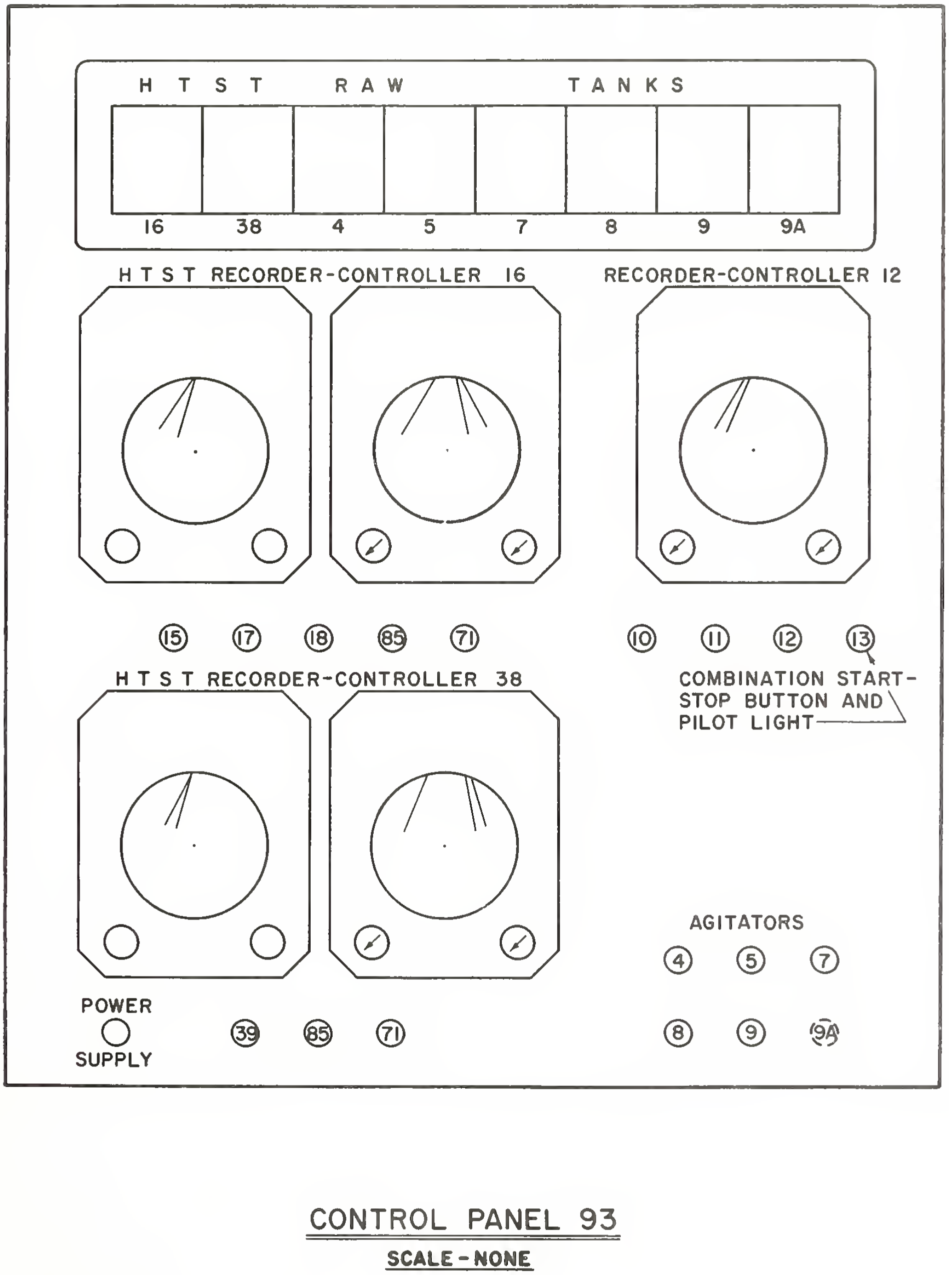


FIGURE 2.—A suggested control panel for HTST record-controllers and indicators for raw milk tanks and pasteurized product tanks.

stainless steel and the vane and bearings are of nonabsorbent plastic. The outlet and inlet are 3 inches across. The rotor turns at 100 revolutions per minute (r.p.m.). The pump capacity is 10,000 pounds per hour.

For cleaning, the operator removes four thumbscrews, then lifts off the body of the pump intact with rotor and impeller so it can be hand washed.

The twin blenders (33) thoroughly mix the curd and dressing. This type of agitation permits the curd to be folded into the dressing to obtain a uniform distribution of the cream, salt, and stabilizer without breaking down the curd or destroying the body of the mixture. Each vat will hold 4,200 pounds of the dressed curd. This amount provides a constant supply of cheese for the packaging machines located below.

Bulk Culture Room

This room is centrally located on the first floor adjacent to the processing area and the superintendent's office and below the laboratory. The door of the culture room leads to a hall which connects with a stairway and an elevator. The room is shaped irregularly and contains about 588 square feet, exclusive of 96 square feet at one corner reserved for the superintendent's office. It is completely enclosed and is pressurized against possible outside air infiltration.

Three 800-gallon vertical jacketed vats (22) with continuous welded channels on the sidewall for rapid hot water heating and sweetwater cooling, provided with a swept surface agitation and variable speed control, are used for bulk culture manufacture. The outlet valve is 2 inches in diameter. Each tank is equipped for CIP cleaning. There is a CIP return pump (81).

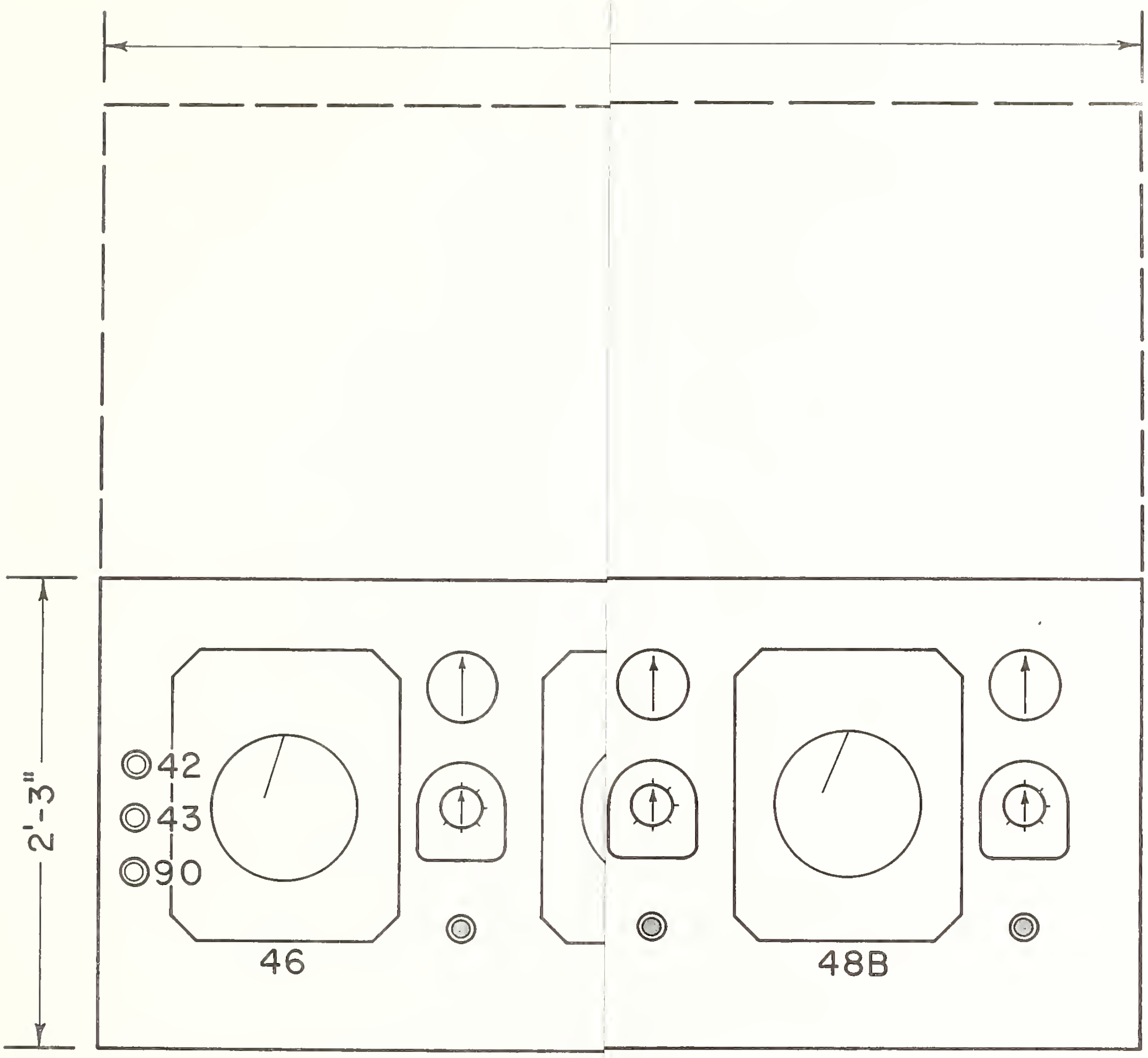
The equipment for injecting calcium chloride into the cottage cheese skim milk is located in this room. It consists of a 50-gallon calcium chloride mixing tank (23) and a calcium chloride metering pump (24). The need for calcium chloride varies with the milk, the season, the feed of the cows, and the heat of pasteurization. Spring and fall are the most likely times of year that the addition of calcium will be necessary. The maximum amount needed is about 0.02 percent, or 4 pounds per 2,400 gallons of skim milk. The salt is diluted with cold water at the rate of 4 pounds of salt per 24 pounds of water. When 0.02 percent of the calcium salt is used, the amount of solution needed for each 2,400-gallon preset vat (21) would be 28 pounds. This is added by the laboratory technician through the metering pump (25) at the time the culture is metered into the line leading to the preset vats (21). By adding calcium chloride, a firmer set is obtained and a better yield results, since there is less shattering of the curd.

The room is isolated from the rest of the plant as far as free access is concerned to minimize the possibility of contamination of the starter and cottage cheese skim milk. No one is permitted to enter the room except the laboratory technician who handles the culture. The central location of the room and the closeness of the stairway and elevator minimize the distance the technician needs to travel in the plant, thus reducing the possibility that he will become contaminated with bacteriophage or undesirable bacteria brought into the plant from outside sources.

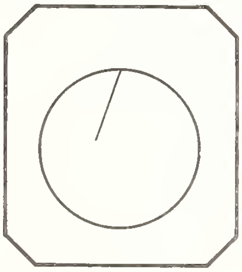
Cultured Milk, Cultured Cream, and Cream Cheese Processing Room

This room is adjacent to the cottage cheese creaming area but at a level 4 feet higher. The areas are connected by a stairway. On another side of the room is a stairway leading to the first floor. The room is 49 by 49 feet, containing about 2,400 square feet. The equipment includes three 1,000-gallon cultured cream vacuum-pressure jacketed vats (46) with continuous welded channels on the sidewall for rapid hot water heating and sweetwater cooling, with swept surface agitation and variable speed control. The valve outlet is 3 inches in diameter. The vat is equipped for in-place cleaning.

Two 1,500-pound kettles (54) are required for processing cream cheese. Each kettle has a stainless steel cover, a 2-inch flush valve, and a hydraulic lift for tilting the agitators out of the cooker for cleaning. The bowl has a 200-gallon capacity with the inside diameter 36



LEGEND


RECORDING THERMOMETER

ION START-STOP

START BUTTON
LIGHT

BUTTONS

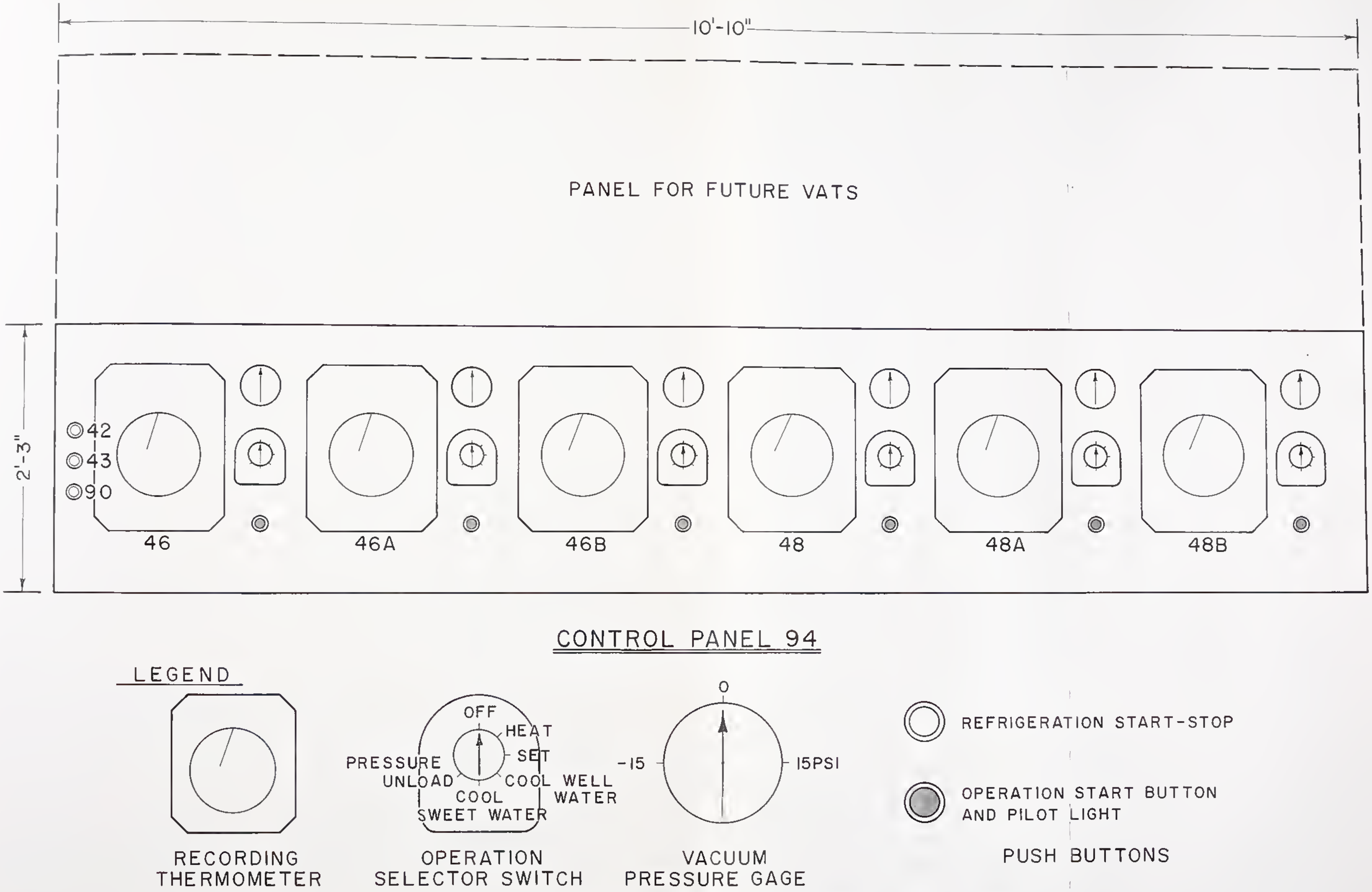


Figure 3.—A suggested control panel for controlling pressures and temperatures for cultured products vats.

inches. The height to the brim is 61 inches. The kettles are mounted on load cells.

The curd concentrator (53) is used to separate the curd from the whey in making cream cheese by centrifugal action in an enclosed system in a continuous operation. Use of this machine eliminates the need for draining bags used in the conventional method, thus greatly reducing the time required to produce the cheese. Also, there is less chance for bacterial contamination of the curd; the product is more uniform in composition; the yield is higher since there is less fat or curd loss; and the labor involved is about one-third that used in the bagging method. The curd concentrator has an input capacity of 900 gallons of mix and an output of 1,000 pounds of curd per hour.

The machine functions somewhat like a cream separator, separating the curd from the whey by a disc-type bowl. The curd is forced down the disc and against the bowl wall while the whey is forced toward the center and into an outlet. The curd remains against the bowl wall until it reaches a concentration of about 25 percent solids, when it is forced through nozzles in the bowl wall. The curd enters a stainless steel cover that is sloped toward an opening through which it is discharged and collected for further processing.

A positive displacement feed pump (52), 900 gallons per hour, for the curd concentrator is located near the vats used for setting the cream cheese (48).

A 125-gallon-per-hour homogenizer feed pump (55) and a 125-gallon-per-hour homogenizer (56) are supplied for processing the cream cheese.

For cultured milk and cream cheese mix three 2,000-gallon vertical vats (48) are used which are jacketed for hot water heating and sweetwater cooling. These vats contain swept surface agitation and a variable speed control. The valve outlet for the tank is 3 inches in diameter, and each tank is equipped for CIP cleaning.

For the storage of pasteurized cream, a 2,000-gallon coldwall insulated tank (42) equipped for agitation and adapted for inplace cleaning is provided. The tank is mounted on load cells (83). The outlet valve is 2 inches in diameter and is air operated.

Tank (43) (identical to tank 42) serves as a storage tank for the cottage cheese dressing. A pump (44) is used to transfer the cheese dressing to tanks (31) and (31A); another pump (45) is used to transfer the sweet cream to wherever it is needed.

Tank (106) (identical to tank (42) except that its capacity is 3,000 gallons) is used to store the surplus cream. Since tank (106) is located on the second floor, the cream can be loaded into tank trucks positioned at the receiving dock below by pump (45).

Control panel (94) is located in this area (fig. 3). This panel centralizes the vat controls for vats (46) and (48). Recording thermometers for each vat are located adjacent to the selector switches for each vat. The CIP return pump (81) is adjacent to the cream tank. A portable CIP return pump (82) and a CIP connecting station (80) are provided as well as a COP cleanup tank (78).

Laboratory

The split-level position of the laboratory is designed to provide observation of, and quick access to, all areas of activity. A plate glass partition permits observation of milk receiving, pasteurizing, milk separation, packaging, multipurpose culturing and processing, and parts of the cheese manufacturing area. In this way the laboratory workers (or technicans) can observe all processing activity. Furthermore, this location enables the technicians to easily contact all areas of active processing. The use of an intraplant communication system provides immediate communication with the various workers regarding standardization of products, breaking the curd for cultured products, the cleaning equipment, and other pertinent operations. An anteroom adjacent to the entrance is used by the technicians to change clothes and wash before entering the laboratory.

A control panel (92) (fig. 4) is located in the laboratory and is operated by the laboratory technicians to perform the following functions:

1. Indicate weights of:
    - a. Load cell recordings of bulk receiving tanks (4, 5)
    - b. Preset vats (21)
    - c. Vats for draining curd and adding dressing (31)
    - d. Blending vats (33)
    - e. Dressing storage tank (43)
    - f. Cream storage tank (42)
    - g. Cream cheese kettles (54)
    - h. Surplus cream storage tank (106)
2. Indicate the following temperatures:
    - a. Skim milk and cream pastuerization
    - b. Preset vats (21)
    - c. Stored raw milk
    - d. Cheese dressing and cream storage tanks
    - e. Laboratory coldroom
    - f. Bulk culture vats (22)
3. Automatic valve control for valves located at:
    - a. Dressing tank (43)
    - b. Cream storage tanks (42, 106)
    - c. Preset vats (21)

The laboratory is equipped with the following items:

1. Refrigerators for composite milk samples, the size depending on the number of farmers supplying milk.
2. A small refrigerator for bulk tank delivery samples.
3. Laboratory desk and sinks.
4. A refrigerator for storing samples of all products manufactured and for cheese enzyme.
5. A Mojonnier solids tester.
6. Gerber and Babcock combination tester and equipment for fat tests.
7. Acid dispenser.
8. Autoclave.
9. Hot air sterilizer.
10. Built-in incubator in table unit.
11. Automatic dishwasher in table unit.
12. Fast weighing analytical balance.
13. Waring Blendor.
14. Cheese drying oven.
15. Bacteriological glassware.
16. Dry heat sterilizer for glassware.
17. Intraplant communication system.
18. Control panel.
19. Equipment for making acidity and pH determinations and complete bacterial examinations of dairy products, and water adulteration of milk.

The laboratory includes a 36-square-foot anteroom to a transfer and incubation room (150 square feet) and a passageway and room used for laboratory tests (549 square feet). It occupies a 22- by 37-foot section of the plant.

Air in the laboratory is purified and pressurized, and the temperature is automatically controlled.

The cheese coagulator is stored in the laboratory refrigerator; its use is a responsibility of the laboratory technicians.

Packaging Room

The packaging room contains 1,966 square feet and is located on the first floor below the bulk supply of cottage cheese cream curd, cream cheese, cultured cream, and cultured milk. This location permits gravity feed into the packaging machines. The packaging room is between the cold storage room and the dry storage room. Thus, the empty cartons can be easily moved into position for filling and placing in boxes, which are then conveyed to the cold storage room and placed on pallets.

Three machines (34) are used for filling cottage cheese and cultured cream packages. They can be set to fill 25 to 100 containers per minute. The variable speed drive provides timing to a hopper-filling operation. The direct action positive metering valve will fill cartons within an accuracy of $^{2}/_{10}$ounce. Change parts are available for 8-, 12-, and 16-ounce heavy duty containers, 12- and 16-ounce semisquat heavy duty containers, and 32-ounce tall heavy duty containers.

An adapter for connecting filling valve to gravity feed line is supplied. A conveyor for attachment to automatic box former and caser (36) is engineered into the job. The capper assembly includes capper head, lid magazine, and shuttle, available in the various sizes of cups to be used.

The availability of several types of nozzles makes possible clean filling for both cottage cheese and cultured cream. In addition to a no-cup, no-lid protection, an automatic no-cup,

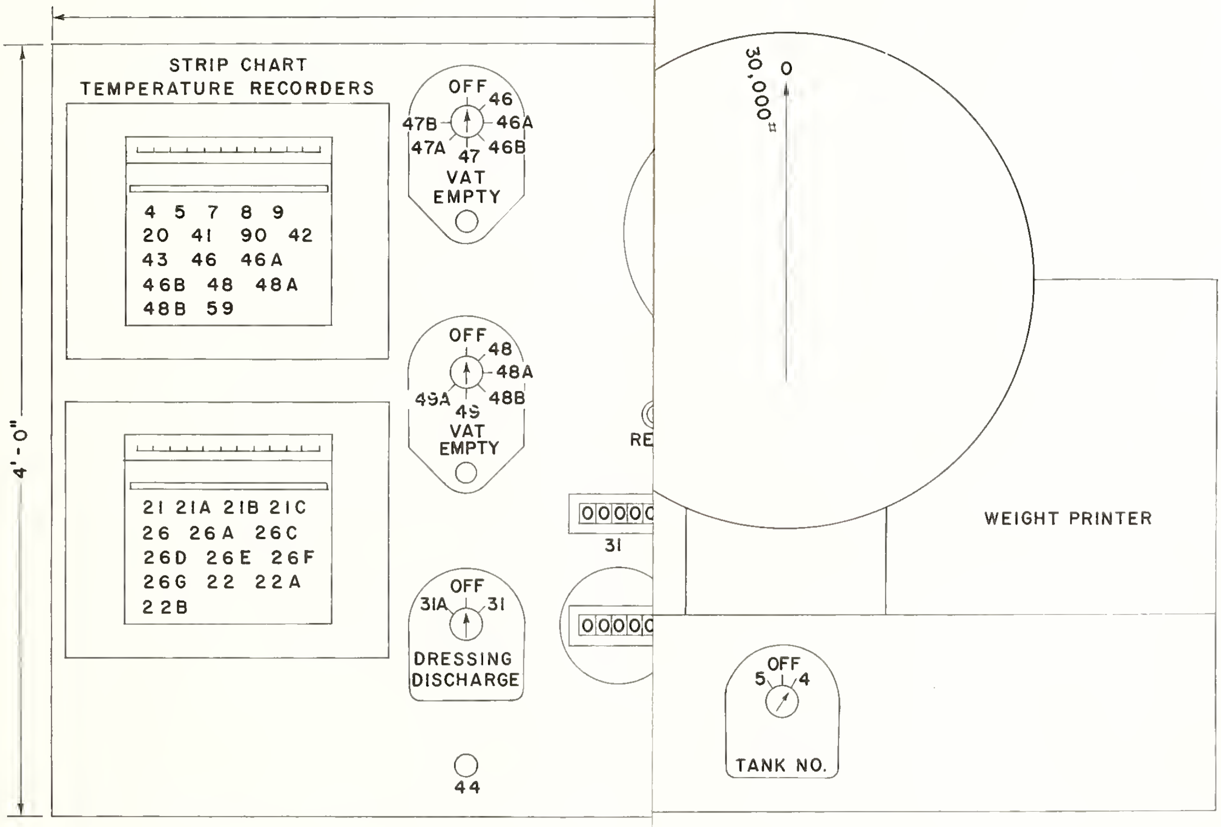


FIGURE 4.—A sugg nilk weekly.

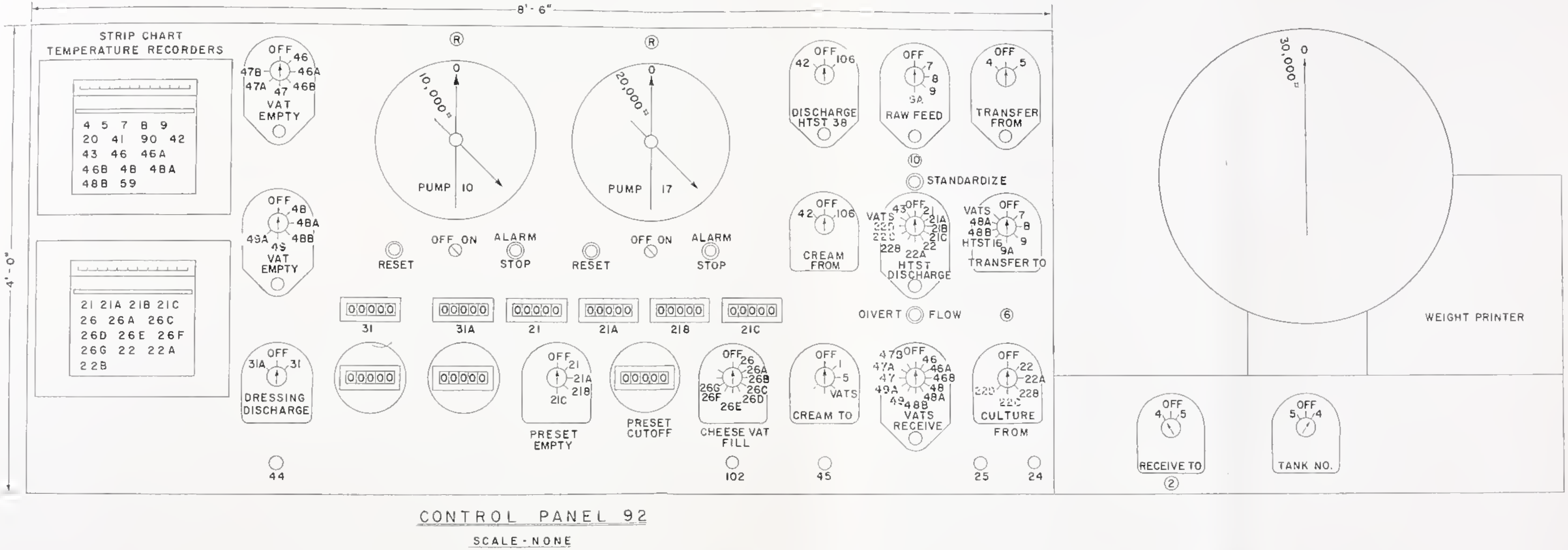


FIGURE 4.—A suggested control panel for receiving milk and handling processing operations in a plant handling 1,200,000 pounds of whole milk weekly.

no-fill control is built into the machine. A bottom ink coder makes possible the coding of all packages for later checking.

The 4-inch line connecting the blender (33) and the bulk packaging machine (35) is equipped with a sliding valve. The 50-pound plastic bag inserted inside a fiberboard container is filled with creamed cottage cheese through this valve. The carton is supported by scales set to weigh 50 pounds.

Cream cheese packaging machine.—This machine (58) is especially designed for handling semiplastic products and is constructed of stainless steel and high-tensile aluminum. All surfaces exposed to the product are stainless steel. It has an air ejection system to remove completed packages and features a no-wrap, no-product safety device. The cream cheese is fed from a 225-pound-capacity stainless steel double-walled hopper that is heated with hot water to maintain product temperature at approximately 165° F. The machine will deliver the required package weight within a tolerance of 1 gram.

In filling the 3- and 8-ounce packages, the nozzle enters the formed pouch to almost the bottom before the product begins to enter. As the pouch is filled, the nozzle is gradually retracted until the full part has been delivered. At this point, the nozzle is given a slight quick snap to prevent dripping between fills.

A plate makes a top fold that covers the complete surface area with wrap material leaving one sixteenth-inch overlap to form a coating-to-coating seal. Fingers form the second or side folds. The package then has the last flap "plowed" down to where at the last station the completed closure is given a firm but gentle tap to assure positive contacts for a seal. The wrap material is 0.00045-inch overcoated foil laminated to tissue, which is covered with a special coating.

The overall dimensions of the machine are 9 feet 7 inches by 3 feet 4 inches.

Cultured milk-filling machine.—This machine (50) is used for filling plastic-coated paper quarts and half-pint containers with cultured milk. The capacity of this machine is 75 units per minute and requires 6 feet $5^1/_2$ inches by 16 feet $8^1/_4$ inches of floorspace. The volume of the tank with automatic float control is 9 gallons. The machine has a self-contained air compressor unit.

Box former.—This is a portable machine (103) that takes the shipping box from a stack of flats, opens it, folds the bottom flaps, and sends it on to the caser. The bottom flaps are folded and pushed into the box beyond their final position. This prebends the scores so that the empty boxes ride flat on the conveyor.

Caser.—The caser (51) automatically places the filled cartons of cultured milk into the formed fiber boxes. The machine will place 16 quarts or 44 half-pints (in two layers) in a box. After being filled by the caser, the boxes are glued and sealed by a box sealer (104) at the rate of 30–32 per minute. Above-floor conveyor (86) moves the cases of cultured milk from the box sealer into the cold storage room.

A COP cleanup tank (78) is provided for cleaning dismantled equipment.

Cold Storage Room and Shipping Dock

This area has sufficient space to contain 1 day's full production of all items. However, this amount of space will seldom be needed since the loaded pallets usually will be transferred directly to the truck trailers as they are filled. One or more trailers should be available at all times during filling operations. Each truck with its refrigeration constantly in operation will function as an auxiliary coldroom. Each trailer is to be loaded by order; that is, with an assortment of various products consigned to their respective markets. When possible, each truck will be loaded to capacity, which is 18 pallets.

The size of the cold storage room needed to store one day's full production is calculated as follows:

Cream cheese

1. 3-ounce units—16,000
   Size—3 x $2^1/_{16}$ x $^{15}/_{16}$ inches
   Packed 6 per box in inner pack

   Inner packs required—2,666
   Size—$9\frac{1}{2}$ x $4\frac{1}{2}$ x $^{15}/_{16}$ inches
   Packed 24 per box in large pack

Large or outer packs required—111
Size—8 x $13^{7}/_{8}$ x $9^{7}/_{8}$ inches
Stacked 90 boxes per pallet

Pallets required—$1^{1}/_{2}$

2. 8-ounce units—6,000
   Size—$4^{5}/_{8}$ x $1^{1}/_{4}$ x $2^{9}/_{16}$
   Packed 6 per box in inner pack

   Inner packs required—1,000
   Size—8 x $9^{1}/_{2}$ x $1^{3}/_{8}$ inches
   Packed 12 per box in large pack

   Large or outer packs required—83
   Size—$16^{1}/_{4}$ x 10 x $10^{1}/_{8}$ inches
   Stacked 56 boxes per pallet

   Pallets required—$1^{1}/_{2}$

Cultured cream

1. 8-ounce units—40,000
   Packed 24 per box in fiberboard case

   Fiberboard cases required—1,666
   Size—$11^{15}/_{16}$ x $4^{9}/_{16}$ x $15^{7}/_{8}$ inches
   Stacked 7 cases per layer, 13 high, 91 per pallet

   Pallets required—18

Cottage cheese

1. 12-ounce units—20,510
   Packed 24 per box in fiberboard case

   Fiberboard cases required—855
   Size—$13^{1}/_{16}$ x $5^{5}/_{16}$ x 17 inches
   Stacked 6 cases per layer, 11 high, 66 per pallet

   Pallets required—13
2. 16-ounce units—15,382
   Packed 24 per box in fiberboard case
   Fiberboard cases required—641
   Size—$14^{3}/_{16}$ x 6 x $18^{15}/_{16}$ inches
   Stacked 4 cases per layer, 10 high, 40 per pallet

   Pallets required—16
3. 50-pound containers—264
   Palletized 12 drums per layer, 3 high, 36 per pallet

   Pallets required—8

Cultured milk

1. Quarts—24,500
   Packed 16 bottles per case in single-service case

   Cases required—1,531
   Stacked on pallets, 36 per pallet

   Pallets required—43
2. Half-pints—24,500
   Packed 32 bottles per case in single-service case

   Cases required—766
   Stacked on pallets, 36 per pallet

   Pallets required—22

Daily cooler space needed

Monday and Thursday

Pallets—123
Square feet [2]—1,968

Tuesday, Friday, and Saturday
Pallets—59
Square feet—944

Cultured milk is produced twice a week, but all of it is not shipped out on these two days. Part of the cultured milk produced on Monday and Thursday, therefore, will be kept in the cooler for loading out on Tuesday and Friday, respectively. The extra available space on Tuesday and Thursday will easily accommodate the milk that is held over.

Space must be provided in the cold storage room for operating the lift truck and the conveyor (86) and storing pallets. For these purposes, 832 square feet is allowed. The arrangement of the pallets and aisle space in the cold storage room is shown in the plant layout.

The cold storage room contains 2,800 square feet. The temperature of the room is maintained at 35° F. by six ceiling hung cooling units (64). The door onto the shipping dock is 8 feet wide so as to provide ample space for a lift truck. The door opening into the packaging room is only 6 feet wide since a lift truck enters this room only infrequently. Both doors are operated mechanically. The door is opened by pulling an overhead cord. A photocell beam, interrupted as the truck enters, keeps the door open until the vehicle has cleared the doorway. An adjustable timer actuates closing. It works in either direction. The beam remains broken until entry is complete, preventing inadvertent closing. The door is available with controls as a complete unit.

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[2] Allowing 16 square feet per pallet.

The shipping dock, 16 feet wide and 100 feet long, provides space for 10 trucks. An 8-foot-wide door opens onto the dock from the cold storage room. At each end of the dock is a stairway. The 15,000-gallon insulated cheese wash water storage tank (29) is located near one end of the shipping dock.

Dry Storage Room and Dock

The dry storage space was calculated for a 2-weeks supply, with the exception of the single-service paper boxes to be used for shipping the cartons of cultured milk. These boxes, being bulky, will be stored in quantities sufficient for 10 days' maximum needs. The following floorspace will be needed:

Cultured milk containers.—The plant will need 196,000 cartons, of which 98,000 will be quarts and 98,000 half-pints. This 2-week supply will be shipped to the plant in cases on pallets, $4\frac{1}{2}$ by $2\frac{1}{3}$ feet. Each pallet holds 30 cases of cartons with 500 quart cartons per case and 1,000 half-pints per case. A total of 11 pallets will be needed, 7 for the quart cartons and 4 for the half-pints. To store these pallets, 115 square feet of floorspace is needed ($11 \times 4\frac{1}{2} \times 2\frac{1}{3}$ feet).

Cultured cream containers.—All containers shipped in cartons with tubs and lids separate. This plant requires 240,000 tubs and lids each for a 2-week supply. A carton 29 x 17 x $21\frac{1}{2}$ inches will hold 1,000 tubs and can be stacked 4 high, requiring 3.42 square feet of floorspace. A carton holds 1,500 lids, can be stacked 4 high and requires 3.03 square feet of floorspace. Total floorspace required:

$$\text{Tubs} - 3.42 \times \frac{240{,}000}{4{,}000} = 205 \text{ sq. ft.}$$

$$\text{Lids} - 2.5 \times \frac{240{,}000}{6{,}000} = 100 \text{ sq. ft.}$$

Total .... 305 sq. ft.

Cottage cheese containers.—Three sizes of containers are needed.

1. 16-ounce carton:

Two weeks' supply requires 153,820 units. Tubs and lids are received separately. A box 23 x 19 x 19 inches holds 1,000 tubs. Tubs are stacked 4 high and a stack requires 3.03 square feet. A box 24 x 19 x 19 inches holds 2,000 lids and can be stacked 4 high, requiring 3.17 square feet per stack. Total floorspace required:

$$\text{Tubs} - 3.03 \times \frac{153{,}820}{4{,}000} = 117 \text{ sq. ft.}$$

$$\text{Lids} - 3.17 \times \frac{153{,}820}{8{,}000} = 61 \text{ sq. ft.}$$

Total .... 178 sq. ft.

2. 12-ounce carton:

Two weeks' supply requires 205,100 units. Tubs and lids are received separately. A box 22 x 18 x 19 inches holds 1,000 tubs. Tubs are stacked 4 high, requiring 2.75 square feet. A box 21 x 17 x 19 inches holds 2,000 lids. Lids can be stacked 4 high and require 2.47 square feet per stack. Total floorspace required:

$$\text{Tubs} - 2.75 \times \frac{205{,}100}{4{,}000} = 141 \text{ sq. ft.}$$

$$\text{Lids} - 2.47 \times \frac{205{,}100}{8{,}000} = 64 \text{ sq. ft.}$$

Total .... 205 sq. ft.

3. Bulk containers:

These are shipped knocked down in bundles of 25 with a polyethylene bag and two circles in each container. Knocked down dimensions—$20\frac{1}{2}$ x 16 x $\frac{3}{4}$ inches. Bundles are 16 inches high; can be stacked 7 high; 175 units require 2.28 square feet. Two weeks' supply: 2,640 units. Total floorspace required:

$$2.28 \times \frac{2{,}640}{175} = 34 \text{ sq. ft.}$$

Paper boxes for packaged units.—Boxes are shipped knocked down in bundles of 5.

1. Cultured cream:

Bundles of 25—17 x 20 x 16 inches. Can be stacked 7 high; 175 units require 2.36 square feet. Two weeks' requirement: 10,000 units (24 per box—240,000 units). Total floorspace required:

$$2.36 \times \frac{10{,}000}{175} = 135 \text{ sq. ft.}$$

2. 12-ounce carton for cottage cheese:

Bundles of 25—$18\frac{1}{2}$ x 22 x 16 inches. Will stack 7 high; 175 units require 2.8 square feet. Two weeks' requirement—8,545 units (24 per box—205,100 units). Total floorspace required:

$$2.8 \times \frac{8,545}{175} = 137 \text{ sq. ft.}$$

3. 16-ounce carton for cottage cheese:

Bundles of 25—20 x 25 x 16 inches. Will stack 7 high; 175 units require 3.5 square feet. Two weeks' requirement—6,409 units (24 per box—153,820 units). Total floorspace required:

$$3.5 \times \frac{6,409}{175} = 128 \text{ sq. ft.}$$

Cream cheese containers and supplies.—Foil rolls shipped in narrow drums require insignificant storage space, about 2 to 3 square feet.

1. 3-ounce inner packs:

Knocked down 13 x 5 x ¼ inches in bundles of 100. Will stack 3 high; 300 units require one-half square foot. Two weeks' requirement—15,996 units. Floorspace required:

$$0.5 \times \frac{15,996}{300} = 27 \text{ sq. ft.}$$

2. 3-ounce outer packs:

Knocked down 25- x 21-inch bundles of 25. Require 16 inches in height and 3.6 square feet; stack 7 high. Two weeks' requirement—666 units. Floorspace required:

$$3.6 \times \frac{666}{175} = 14 \text{ sq. ft.}$$

3. 8-ounce inner packs:

Knocked down 17 x $11\frac{1}{4}$ inches in bundles of 100. Stack 3 high; 300 units require 1.3 square feet. Two weeks' requirement—6,000 units. Floorspace required:

$$1.3 \times \frac{6,000}{300} = 26 \text{ sq. ft.}$$

4. 8-ounce outer packs:

Knocked down 26 x 18 inches in bundles of 25 require 16 inches in height and 3.2 square feet stack 7 high. Two weeks' requirement—500 units. Floorspace required:

$$3.2 \times \frac{500}{175} = 10 \text{ sq. ft.}$$

Cleaners and sanitizers.—Eight drums (2 acid, 2 alkali, 2 sanitizer, 2 general cleaner). Store 4 drums per pallet; requires 2 pallets, Floorspace required:

[3] 22 sq. ft.

Salt.—Twelve 100-pound bags stored on one pallet. Floorspace required:

[3] 11 sq. ft.

Farm supplies.—(Bulk line cleaner, sanitizers, spray, calf starter, etc.) Requires 2 pallets:

[3] 22 sq. ft.

Calcium chloride and laboratory supplies.—Requires 2 pallets:

[3] 22 sq. ft.

Milk solids-not-fat.—Twenty-four 100-pound bags, 12 per pallet. Floorspace required:

[3] 22 sq. ft.

Single-service delivery boxes for cultured milk.—Delivery boxes for cultured milk are shipped knocked down and are assembled automatically just before using. The boxes are shipped 24 to a bundle; each bundle is 12 in. thick, 26 in. long, and $23\frac{1}{2}$ in. wide. Each pallet will hold 4 bundles stacked 2 high, or 8 bundles of 24 boxes each for a total of 192 boxes per pallet. The weekly needs for these boxes are as follows:

$$\begin{array}{lcl} \text{Quarts} & \dfrac{49,000}{16} & = 3,063 \\ \text{Half-pints} & \dfrac{49,000}{44} & = 1,114 \\ \text{Total boxes} & & = \underline{\underline{4,177}} \\ \text{Pallets} & \dfrac{4,177}{192} & = 22 \end{array}$$

Floorspace required:

22 x 11 (sq. ft. per pallet) = 242 sq. ft.

Therefore, 10 days', or 1.5 weeks', supply requires 363 square feet of storage area.

Total area needed for dry storage room:

Items	*Square feet*
Cultured milk containers	115
Cultured cream containers	305
Cottage cheese containers	417
Boxes for cultured cream	135
Boxes for cottage cheese	265
Wraps and packs for cream cheese	77
Cleaners and sterilizers	22

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[3] Based on pallet size of 40 x 40 inches.

Salt bags	11
Farm supplies	22
Calcium chloride and laboratory supplies	22
Bags for dried milk	22
Single-service boxes for cultured milk	363
Total area needed for supplies	1,776
Allowed for aisle space	821
Total area for supplies and aisles	2,597

The dry storage room is 49 feet wide and 53 feet long and contains 2,597 square feet. There are two 8-foot doors, automatically controlled, for this room similar to those used in the cold storage room. The room is equipped with an air conditioning and purifying unit (73) suspended from the ceiling, unit heaters (98, 98A) and racks (88) for double-stacking pallets. One door opens onto a receiving dock and one opens into the packaging room. Where feasible, all freight received will be palletized and will be moved by a lift truck from the storeroom to the packaging room as needed. The dock is 10 feet wide and about 60 feet long. A stairway is located at one end of the dock.

Offices and Locker Rooms

The overall area of the general offices is 2,590 square feet; the length is 74 feet and the width is 35 feet. The manager's office and the sales manager's office are the same size, 12 by 15 feet. The office for the receptionist and clerk is 16 by 20 feet. This room opens to a passageway to the plant and women's restroom and serves for communication between the manager's office and the sales department. The storage room for office supplies is 11 by 15 feet and opens off the accounting area, which is 45 by 18 feet. The air-conditioning unit (97) for the office is located in the storage room. The drivers' check-in room is 20 feet by 14 feet 8 inches. A men's restroom and locker room 10 feet by 14 feet 8 inches is provided for the truck drivers and office employees. There are two entrances to the office; one is the main entrance at the front of the building, and the other is on one side for the drivers.

The office of the plant superintendent is located near the center of operations on the first floor. He can contact the laboratory or the various work stations in the plant by an intraplant communication system. His office is 8 by 12 feet and is equipped with desk, chairs, and filing cabinet. All walls are glass to permit observation of plant operations.

The restroom and locker room for plant workers are located near the plant employee entrance. This area is 24 feet square and contains 576 square feet. Women plant workers will use the restroom of women office workers. The restrooms are equipped with lockers, lavatories, toilets, and first aid facilities.

Adjacent to the men's locker room is the lunchroom, 17 feet 4 inches square, for all employees. Vending machines for candy, hot coffee, and milk are in this room. The lunchroom is furnished with tables, chairs, and waste cans.

Refrigeration Room and Shop, and Boiler Room

These rooms are located near the areas of the plant needing maximum heat and refrigeration. The rooms are at the corner of the building on the ground floor, between the raw milk processing area and the cold storage room. The boiler room is 24 by 31 feet and contains 744 square feet. The refrigeration room and shop are L-shaped and contains 2,165 square feet. In these rooms are located the following items of equipment: Two 250-hp. boilers (60); 36-ton ammonia compressor (65); 48-ton ammonia compressor (66); 60-ton ammonia compressor (67); future 47-ton ammonia compressor (67A); 20-inch by 20-foot ammonia receiver (69); two 75-ton evaporative condensers (68, 68A); 1-ton Freon condensing unit (87) for laboratory coldroom; 2-ton Freon condensing unit (77A) for the air-conditioning and purifying unit (74) on roof for the transfer and incubation room; 15-ton Freon unit (75) for the air-conditioning and air-purifying unit (73) for packaging room, suspended from ceiling; air-conditioning and purifying unit (72) for culture room and laboratory, suspended from ceiling; 12-ton Freon condensing unit (76), cheese washwater cooler (63); 15,600 pounds per hour, purifier for cheese washwater (96); 62,000-pound ice builder (62); 20-hp. air compressor (70); workbench and repair tools (105); equipment access panel (89);

cheese washwater feed pump (95); boiler feed water system (91); hot water heater (101); sweetwater circulating pumps (71); future sweetwater circulating pumps (71A); future ice builder (62A), unit heater suspended from ceiling (98); hot water heating and circulating pumps for HTST systems (85); and electric distribution panel (90).

Garage

All the business is wholesale, and some of the product will be picked up at the dock by the buyer. Most of the deliveries will probably be made to large supermarkets. It is assumed, therefore, that four refrigerated cold-plate trailer trucks, each with a capacity of 60,000 pounds, will be used. The garage is large enough for four truck stalls, a grease rack, and a wash station. Each stall has a power-operated door. In cold climates, the garage should have facilities for winter heating. Each truck has electrical connections to operate the self-contained refrigeration units. The trucks are 32½ feet long and 8 feet wide, and the heights of the bed vary from 54 to 56 inches. They will hold 18 pallets each. The building is 85 feet long and 60 feet wide. The location of the garage in relation to the plant proper is shown on the plot plan.

Incinerator

To dispose of damaged cartons, shipping containers, and other combustible waste material, an incinerator (108) is provided. It is outside the building near the dry storage room.

Provisions for Plant Expansion

The most logical plan for increasing the capacity of this plant, up to double its planned output, is to add a night shift and utilize all cheese vats four times in a 24-hour period. This plan would result in maximum efficiency in the use of the plant and increase its capacity at a minimum cost. To do this, the following extra processing equipment would be needed:

1. Two 2,000-gallon multiprocess vats (49, 49A)
2. Three 1,000-gallon multiprocess vats (47, 47A, 47B)
3. Two 800-gallon multiprocess vat (22C, 22D)
4. One 8,000-gallon milk storage tank (9A)
5. One 2,000-gallon cream storage tank (not shown on the layout, since the purchase of this equipment can be avoided by arranging more frequent delivery of the surplus cream).

The only additional space required in the plant for the extra equipment would be in the multiprocess floor area and coldroom and dry storage areas. This extra space could be obtained by expanding the present floor area as shown in figure 1.

The additional raw milk for the increased volume would be delivered between 4:30 p.m. and 9:00 p.m. An additional 15 new plant employees plus another assistant plant supervisor would be needed for the doubled volume.

The same daily sequence of manufacturing operations would be followed; namely:

Monday—cultured milk and cottage cheese, extended into Tuesday.

Tuesday—cultured cream, cream cheese, and cottage cheese.

Thursday—repeat Monday.

Friday and Saturday—repeat Tuesday.

Plant Site

The location of a plant manufacturing cottage and cream cheeses and cultured milk and cream should be near an ample milk supply, preferably outside or at the edge of a city milk shed. The site should be reasonably close to large urban centers and must be connected by hard surfaced roads to a main highway leading to the market to be served.

A location near a small town is desirable so that a local supply of labor will be available. Suitable electrical power and an ample supply of good water are essential. If city sewage facilities are not available, the site chosen must be suitable for the proper functioning of a sewage disposal plant and disposal of the effluent.

The area should have municipal or State snow-removable service, if the climate warrants it, to avoid transportation difficulties. The site should not be near produce markets or waterfronts because of rodents and insects. Locations on side roads are undesirable because they may necessitate passage over bridges not large enough to carry heavily loaded trucks. The site should have gas available or be adjacent to a railroad siding if oil is to be used for heating. Locations near such industries as tanneries, packing houses, or oil refineries should be avoided because of noxious odors.

The type of soil and the grade of the land will influence the cost of building construction. Filled property that has not had a chance to settle, swampy areas, and land composed of soft clay or rocks are not considered good building sites. Swampy locations require pilings for proper support of footings. Excavating in rocky areas is expensive. The most satisfactory base for low-cost foundation construction is either gravel or soft rockbed with a minimum grade providing good drainage.

The site should be large enough to provide ample space around the building for future expansion and for the necessary service roads. Parking space for delivery trucks and employee cars must be available. The lot must be large enough also to provide room for a service garage and shelter for the trucks unless the rolling stock is to be rented from a company that services and stores the trucks while not in use.

A proposed layout for the site for the plant is shown in figure 5. The area is 475 by 315 feet—approximately 3.5 acres. The location is on the corner of a main highway and a side road. Locations of the parking areas and the garage are shown. Local building restrictions may control the location of buildings on the lot.

Schedule for Use of Equipment

Utilization of specific items of plant equipment is shown graphically in figures 6, 7, 8, and 9. Figure 6 gives the time schedule for the utilization of the 800-gallon culture vats (22), the 2,000-gallon cultured milk vats (48), and the 1,000-gallon cultured cream vats (46) over a 24-hour period, Sunday through Saturday. The legend indicates what each tank is being used for and at what stage in the processing each product is each hour of the day.

Figure 7 shows the scheduling of the eight cheese vats (26) on the days cottage cheese is made. This figure shows that two rounds of cheese are being made, starting the first round at 3 a.m. and finishing the last two sets of this round (vats 7 and 8) about 11 a.m. The second round starts at 9 a.m. with the setting of vats 1 and 2 and ends with washing and draining the curd of vats 7 and 8 about 5 p.m.

As this figure shows, if additional curd is needed for any reason, a third round can be started by placing milk in preset vats 1 and 3 at 3 p.m.

Figure 8 shows the hours each of the major items of equipment is in use on a maximum use day for a period of 24 hours, starting at midnight. Figure 9 shows how the major items of equipment would be used if the volume of products were doubled.

HOW THE PLANT OPERATES

Although the general principles are the same, the methods employed by different commercial manufacturers of cottage cheese vary somewhat according to the existing conditions in each plant. Differences in equipment, milk composition, geographical locations, season of the year, and the type of cheese curd desired lead to differences in methods. In localities where Holstein milk predominates, better yields and a better cheese body can be obtained by raising the serum solids to 9.2 percent or higher by adding nonfat dry milk solids to the skim milk before processing.

The same differences exist in the trade in the manufacture of cream cheese and cultured milk and cream. The methods that will be described in this report are those that have been found commercially feasible. This does not preclude the possibility of the existence of other

(*Continued on page 25*)

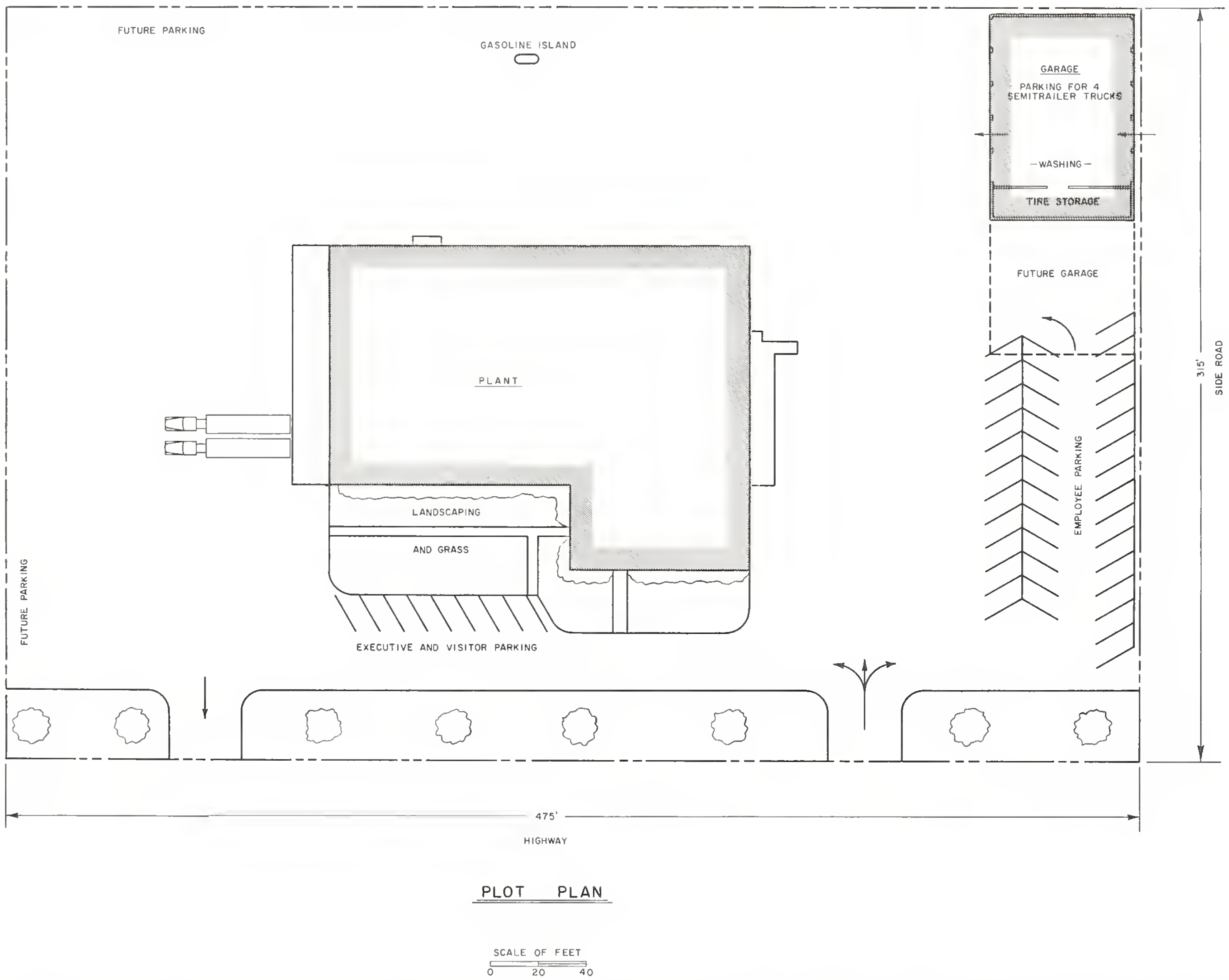


FIGURE 5.—A suggested layout for the site of an automated cottage cheese, cream cheese, cultured milk, and cultured cream plant handling 1,200,000 pounds of milk daily.

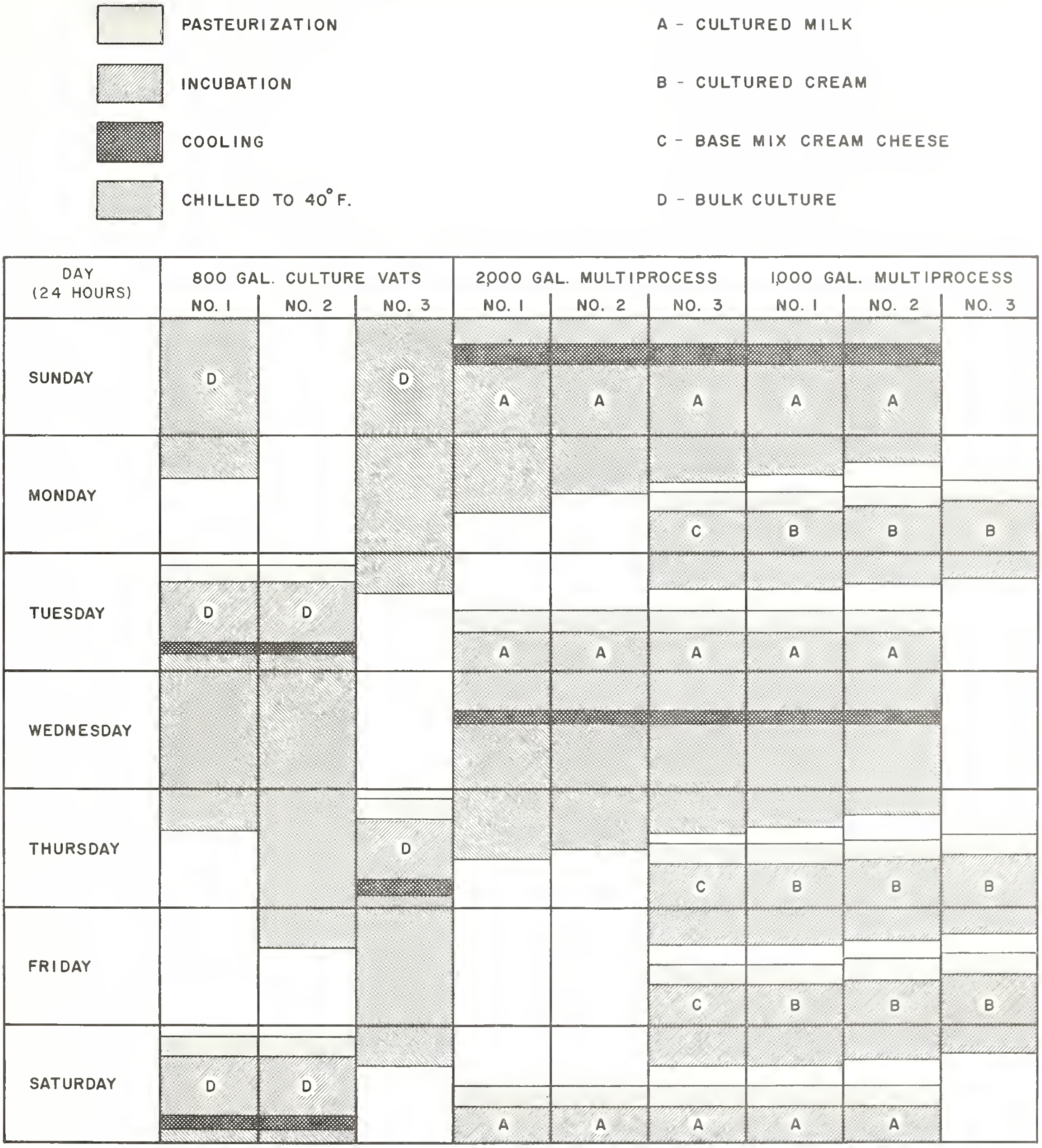


FIGURE 6.—Time use schedule of multipurpose vats.

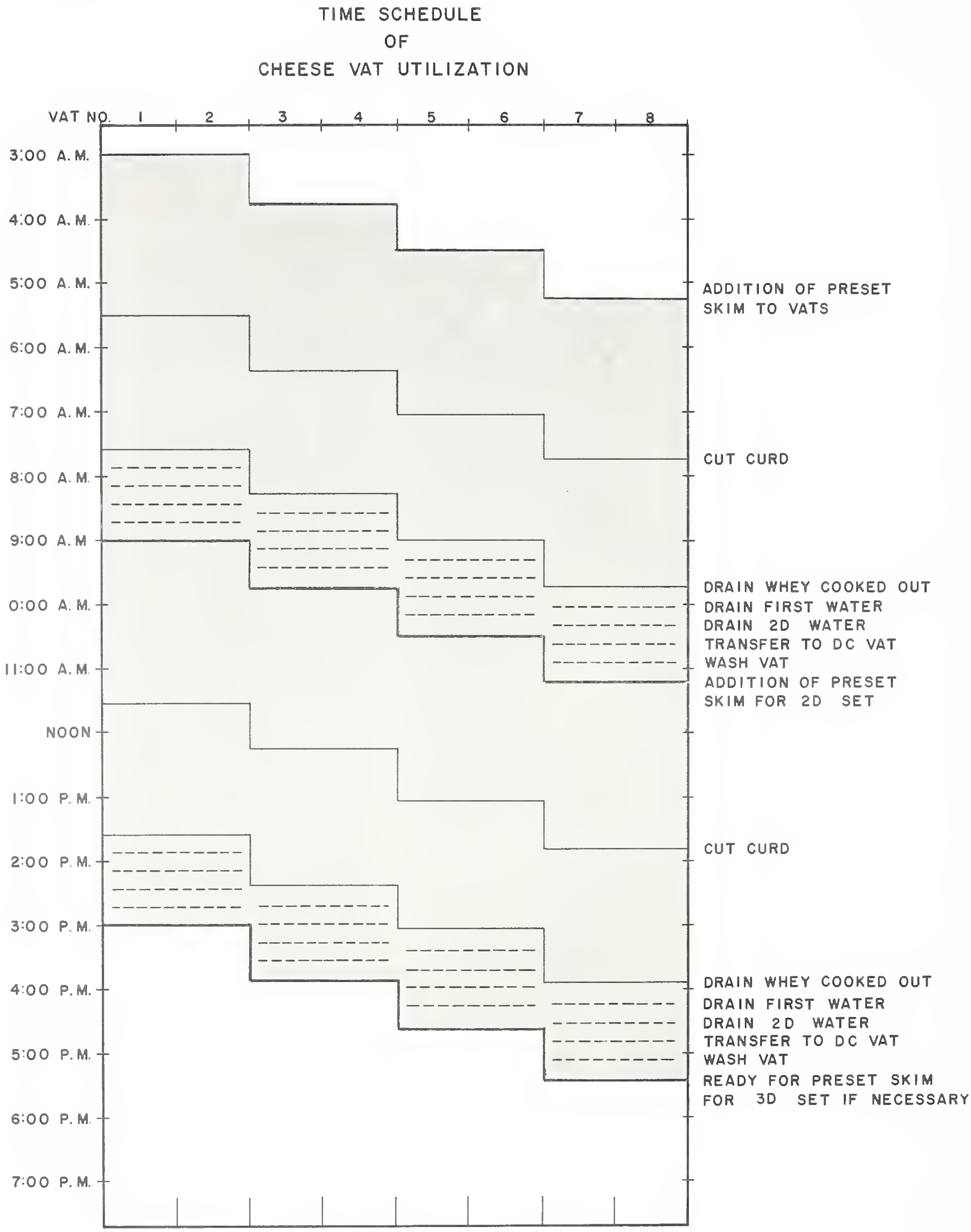
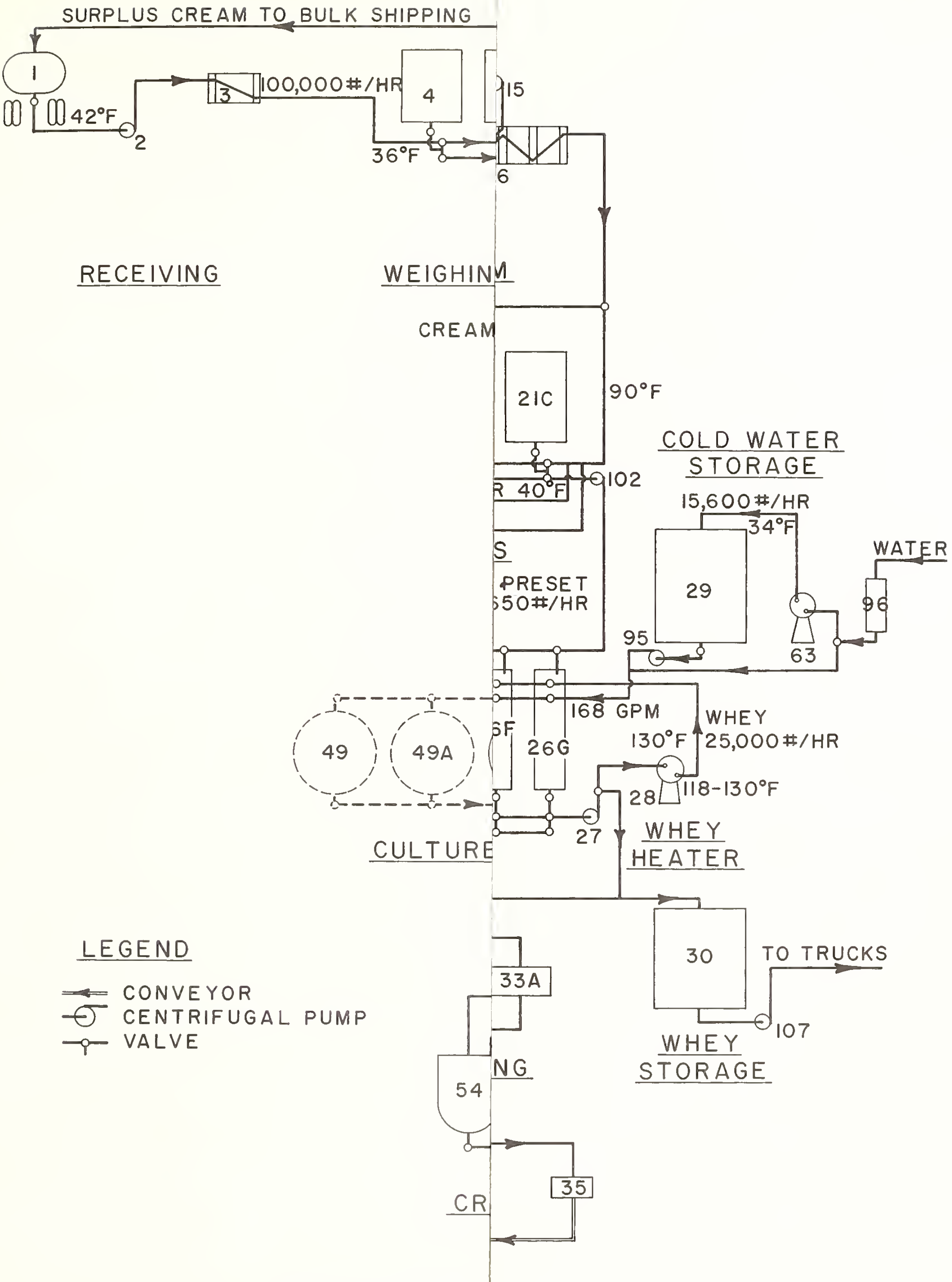


FIGURE 7.—Time schedule of cheese vat utilization.


SURPLUS CREAM TO BULK SHIPPING
1
42°F
2
3
100,000#/HR
4
15
36°F
6
RECEIVING
WEIGHIN
CREAM
21C
90°F
R 40°F
102
COLD WATER STORAGE
15,600#/HR
34°F
WATER
S
PRESET
50#/HR
29
96
95
63
49
49A
F
26G
168 GPM
WHEY
25,000#/HR
130°F
118-130°F
28
27
CULTURE
WHEY HEATER
30
TO TRUCKS
107
WHEY STORAGE
33A
54
NG
35
CR
LEGEND
CONVEYOR
CENTRIFUGAL PUMP
VALVE

FLOW DIAGR

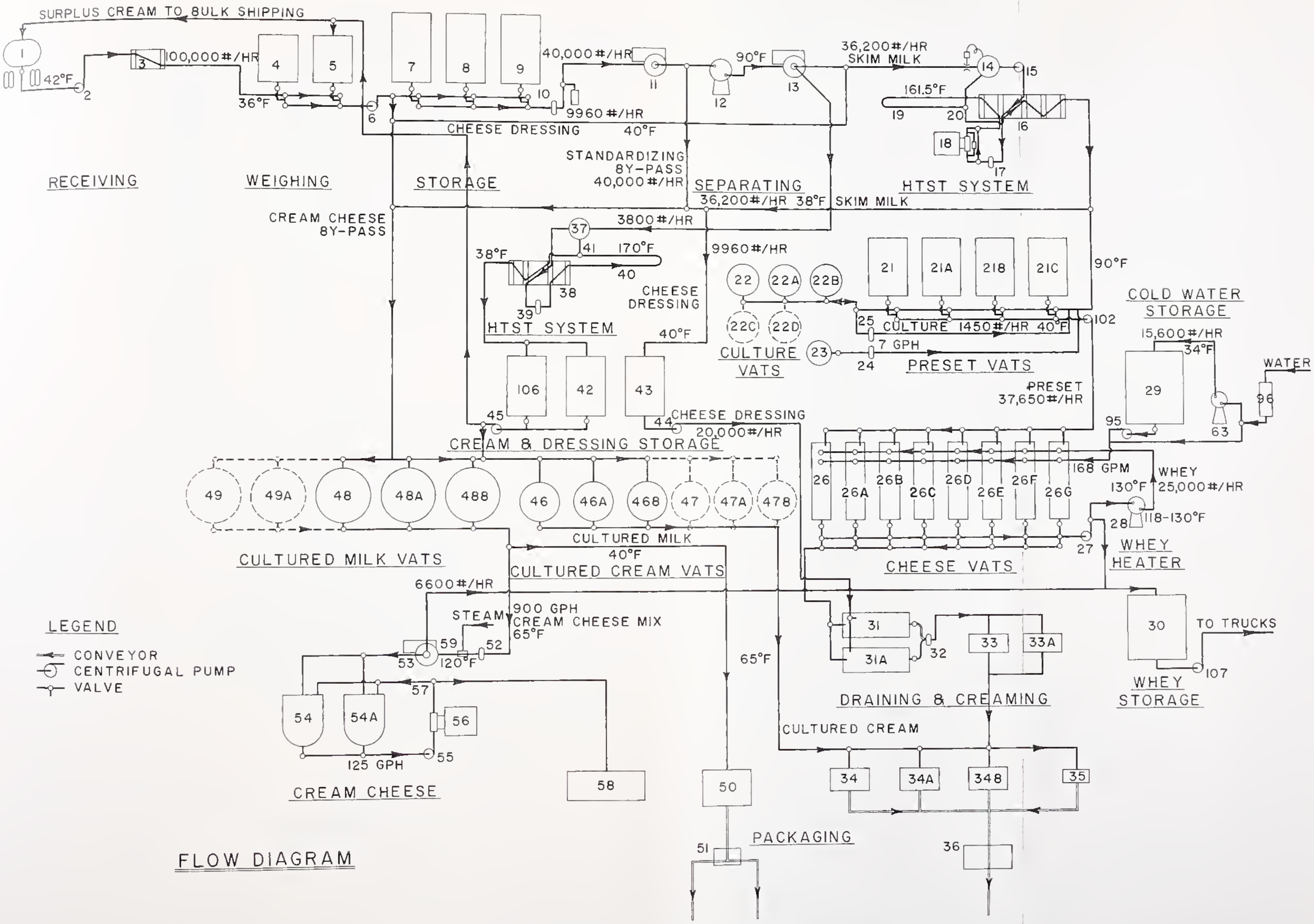


Figure 10.—Flow of milk and manufactured products from receiving through packaging.

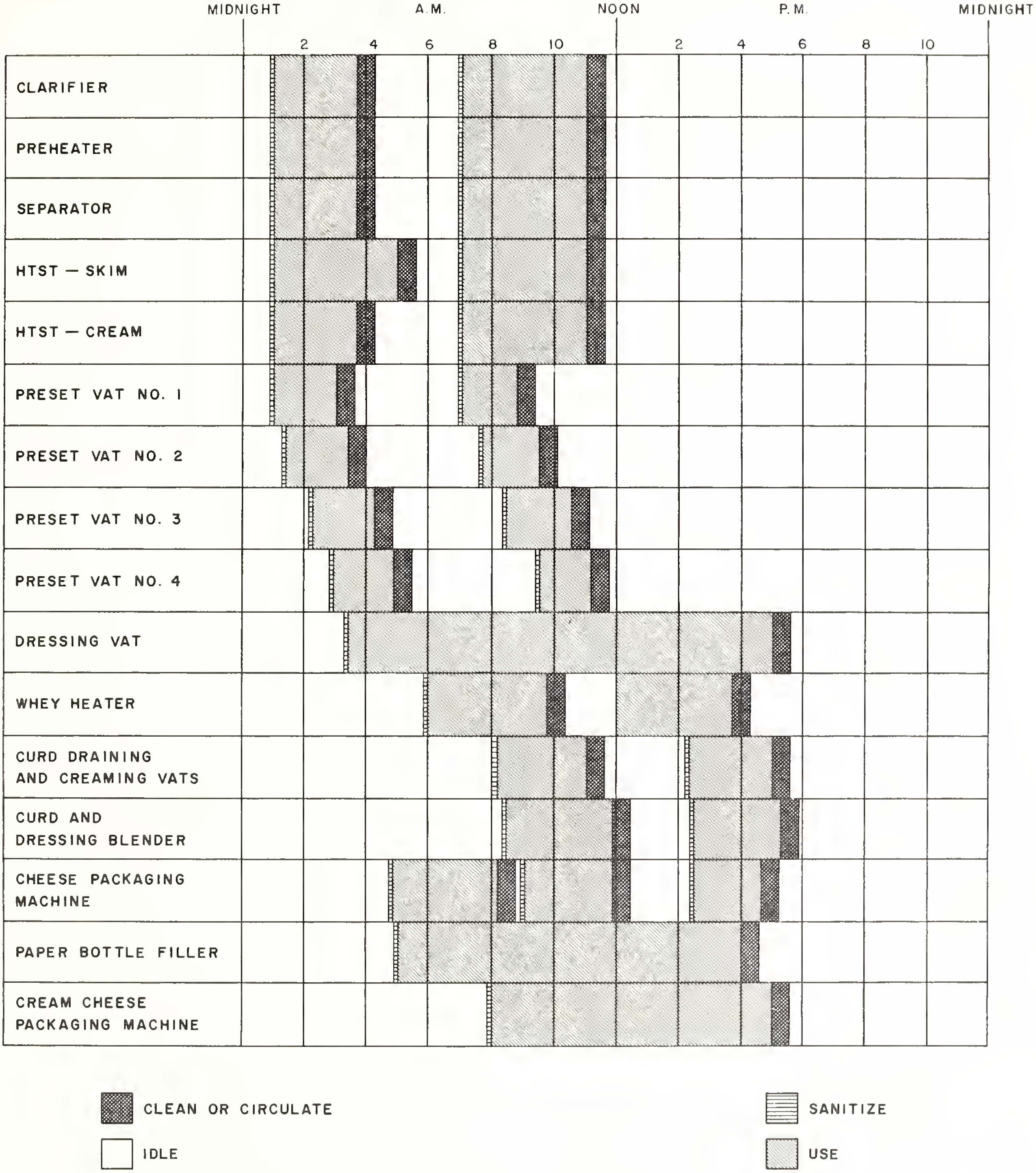


FIGURE 8.—Equipment use schedule based upon maximum day.

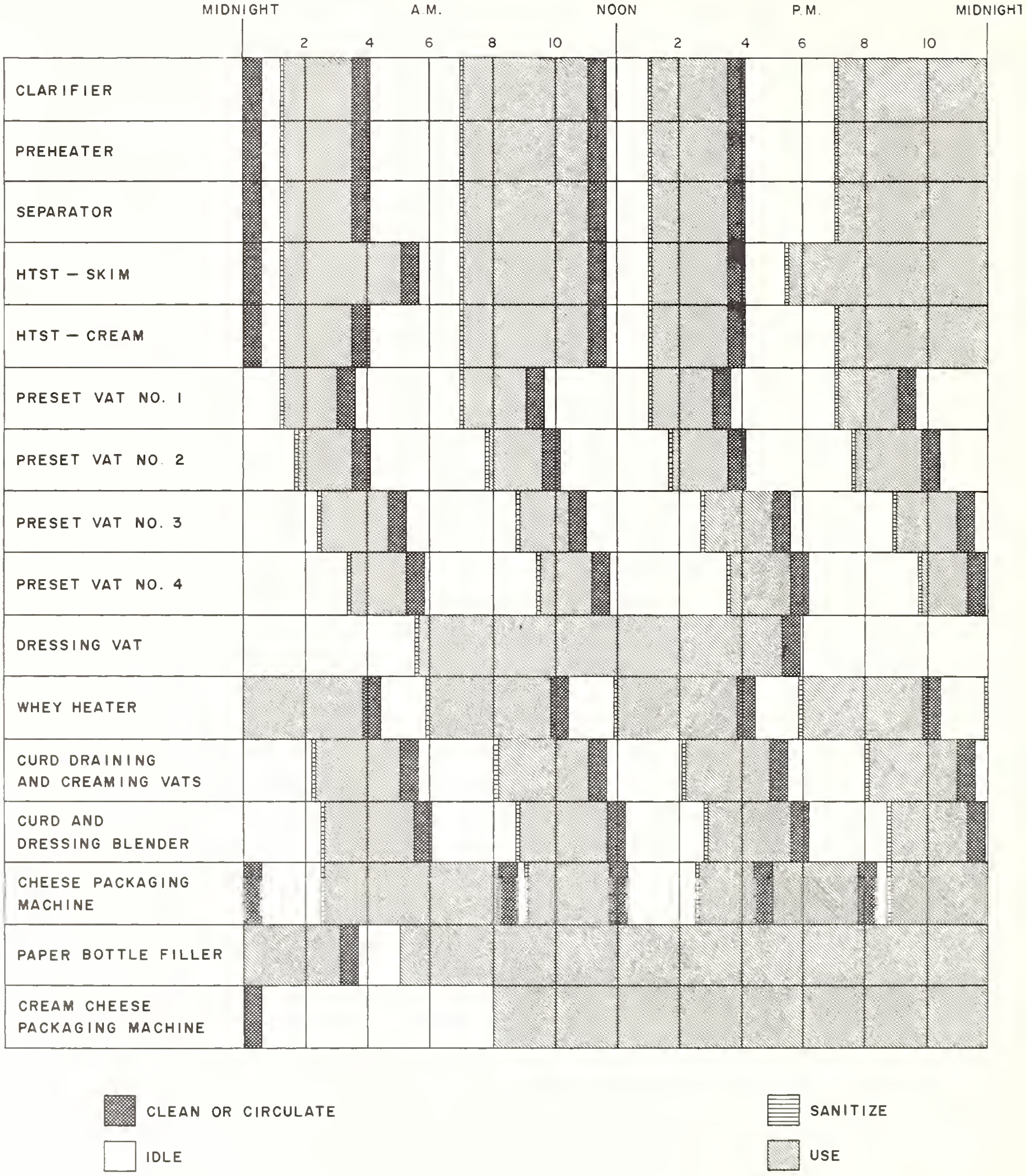


FIGURE 9.—Equipment use schedule based upon maximum day assuming the volume of products is doubled.

desirable methods of manufacture of each of the products discussed.

Plant operations, for this study, include: (1) Receiving and processing whole milk; (2) making cultures; (3) manufacturing cottage cheese; (4) manufacturing cream cheese; (5) making cultured milk; and (6) making cultured cream.

Receiving and Processing Whole Milk

Whole milk is delivered to the plant in ten 2,000-gallon bulk tank trucks (1) between the hours of 4:30 and 9:30 a.m. Pump (2) is used to unload the bulk tank trucks. The milk is pumped through a plate cooler (3) and into one of the two 3,000-gallon tanks (4, 5). After proper agitation a sample is taken into the laboratory for a butterfat test, and the weight of the milk is recorded from the control panel (92) in the laboratory.

Pump (6) moves the milk from the weighing tank into one of the 8,000-gallon storage tanks (7, 8, 9). The only time milk needs to be held in one or both of the 3,000-gallon weighing tanks is during maximum intake. From the 8,000-gallon storage tank another sample of the mixed milk is taken for a fat test.

Cold whole milk is pumped by measure flow pump (10) from the raw milk storage tanks (7, 8, 9) through the clarifier (11), through the preheater (12), where it is heated to 90° F., and then through the separator (13). A flow diagram for milk and manufactured products is shown in figure 10.

The 0.1-percent skim milk, 90° F., is fed directly from the separator into the 36,200-pound-per-hour HTST balance tank unit (14) for pasteurization. An automatic valve at the outlet of the separator controls the flow of skim milk from the separator and synchronizes it with the speed of the HTST unit. From the balance tank the 90° raw skim milk is drawn by pump (15) through the HTST system (16) and pasteurized at 161.5° for 16 seconds. Following pasteurization, pump (17) moves skim milk to (a) culture vats for bulk culture (22, 22A, or 22B); (b) preset vats for cottage cheese manufacture (21, 21A, 21B, or 21C); and (c) cultured milk vacuum pressure vats (48, 48A, and 48B) for cultured milk manufacture. Following pasteurization, all skim milk temperature is automatically adjusted to 90° as it leaves the HTST system with the exception of the milk going to cultured milk manufacture, which is cooled to 38°.

The 40-percent cream, 90° F., coming from the separator enters the balance tank (37) of the 3,800-pound-per-hour HTST system (38) and is pasteurized at 170° for 16 seconds. The positive displacement pump (39) within the HTST system is regulated according to the level of the cream in the balance tank. In the event of an abnormally high level in the balance tank, an alarm sounds in the laboratory and in the processing room. The pasteurized cream is pumped directly into the 2,000-gallon cold-wall cream storage tank (42) which is mounted on load cells.

The receiving and processing of whole milk is handled by control panel (92) located in the laboratory (fig. 4). At the right side of control panel (92) is a weight-indicating dial which is connected to load cells on the 3,000-gallon weigh tanks (4, 5). By turning the selector switch to the proper tank number, the weight of products in either of these tanks may be noted. After the contents of a tank truck have been transferred into tank (4) or (5), a card is inserted into a slot in the side of the weight printer. A button is then pushed which records the weight on the card. This card is the permanent record of the raw milk receipts from the tank truck pick-up routes.

The "Receive To" switch selects the 3,000-gallon tank which will receive milk from the tank truck. Underneath this switch is a combination start-stop pilot-light button to control pump (2). All of the pump control buttons in the panel are of the same type. Each has a pilot light in the center. By pulling the button out about one-fourth of an inch, the start circuit is energized. By pushing it in approximately one-fourth of an inch, the start circuit is broken, thus stopping the pump.

"Transfer From" and "Transfer To" selector switches together with pump (6) control button are used to transfer products from the 3,000-gallon weigh tanks (4, 5) to storage tanks or to further processing in vats (cream cheese) or through the HTST system (cheese dressing). Actuating pump (6) opens the air-operated sanitary valves to direct the flow to the right equipment. If vats are to be filled from tank (4) or (5), the "Transfer To" is set on vats and the "Vats Receive" selector switch is set on the proper vat.

"Raw Feed" selects the 8,000-gallon storage tank which is to provide milk for processing. If the milk is to be separated, pump (10) is controlled from panel (93) (fig. 2). If the milk is for standardizing cultured milk or cultured cream, the "Standardizing" button is pushed, which will route the milk through the standardizing bypass.

Standardization is effected by selecting the vat in which standardization is to take place on the "Vats Receive" selector switch. The quantity required is set on dial "Pump 10" by a movable pointer. This dial is a remotely located revolution counter connected to measure flow pump (10) which delivers a fixed amount of product per revolution. The dial is calibrated in pounds. When the amount set on the movable pointer has been delivered, pump (10) stops, the alarm horn sounds, and the red light over the dial comes on, signaling that standardization is complete. The "Alarm Stop" button stops the horn and turns out the light. "Reset" returns the pointer to zero.

"HTST Discharge" selects the vessel into which the flow is to go. If "Vats" are selected, the actual vat is also selected on the "Vats Receive" selector switch. The amount of product delivered to any vat may be determined by the dial "Pump 17." This pump and dial are similar to that described above, except that upon obtaining the set quantity, the HTST unit goes into forward flow once again. This measure flow pump is for filling vats; the "Divert Flow" button is for changing the flow from one preset tank to another (21) or one culture vat to another (22). By depressing the button when making the tank change, the HTST unit goes into divert flow for a few seconds while the new tank is selected. Divert flow means that the milk is sent from the flow-diversion valve (20) to the balance tank (14) rather than through the downstream part of the HTST system.

The cream from HTST (38) may be sent to tank (42) or (106) by the "Discharge HTST 38" selector switch. The button beneath this selector actuates the air-operated sanitary valve after the selection is made.

Cream may be sent from tank (42) or (106) to a truck tank (1) or to 3,000-gallon weigh tank (5) or to vats by the "Cream From" and "Cream To" selector switches. Cream pump (45) is controlled by pushbutton (45).

Making Cultures

Three types of cultures are prepared in the plant: Mother, intermediate, and bulk. The propagation of mother culture is the phase of culture control that is most important. It involves aseptic transfer and growth of selected strains of bacteria designed to produce the desired results in cheese or cultured milk products. It is the "seed" from which these products originate.

Mother culture is used to make mother and intermediate culture. In this report, an adequate amount of mother culture is assumed to be on hand to make the original preparation.

Intermediate culture is culture between mother and bulk; it is required to prepare bulk culture. Whole milk is used in the preparation of mother and intermediate cultures since the quality of the culture made from the whole milk can be better determined by organoleptic methods. This procedure makes it easier to grade out any of these two preliminary cultures before reaching the final phase of culture making.

Bulk culture is the largest in volume of the three types of cultures prepared. It is used to inoculate large volumes of skim milk for making cultured milk and cottage cheese.

Making Mother and Intermediate Culture

A vital part of the plant operation is the care of mother and intermediate culture. Unless these cultures are kept pure and vigorous, plant operations cannot possibly proceed satisfactorily.

Adjacent to the laboratory is a room which is divided into two parts. One section is a transfer and incubator area, and the other is a coldroom refrigerated at 35° F. Mother and intermediate cultures are made in these areas. The whole area is under slight air pressure. The transfer and incubator area has provision for forced, filtered air ventilation during culture pasteurization. During incubation the temperature is automatically controlled at 71°.

Both sections are completely tiled. They are provided with stainless steel drain traps and have slightly pitched floors (one-half inch per foot). Nonabsorbent, noncorrosive fixtures, doors, pipes, and equipment are provided. The incubating room has a stainless steel washing facility for cleaning pipettes, bottles, thermometers, and other transfer items. Steam, well water, and chilled sweet water are available. An electrically operated hoist is suggested for handling culture cans into and out of the culture vats.

The incubating area provides the equipment required to heat, hold, cool, and incubate the cultures in two stainless steel culture vats. One vat is used for cheese cultures and the other for cultures for making cultured milk and cream. The culture for making cultured milk and cream is incubated at 70° F. for 16 hours and the other at 72° for 12 hours.

Several 10-gallon stainless steel culture cans are provided for the intermediate culture. Each can has a stainless steel agitator with a handle just long enough to extend above the milk and still allow the lid to be closed. The mother culture is carried in glass, which may be pyrex flasks or quart bottles.

Each culture vat holds water up to a height of 1 inch above the top of the milk line in the cans. The glass containers of mother culture are supported in a rack suspended to the depth of the height of milk in the milk cans.

Incidental supplies needed in the incubating area are 8-ml. glass pipettes, $\frac{3}{8}$-in. diameter; parchment paper; foil; milk caps; and rubber bands.

A stainless steel tabletop serves as a transfer area. Air pressure is made available for fogging the rooms with a chlorine solution.

A small anteroom precedes the two areas described above. The room, which is large enough for the technician to remove his outer garments and change his shoes, contains a wash sink. Clean laboratory coats are also available here.

The following rules should be adhered to in making mother and intermediate culture.

1. Only laboratory workers should be permitted in the culture room.

2. Laboratory workers, before entering the transfer and incubation room, must change outer garments and shoes if they have previously walked through the cheesemaking area. They must wash hands and faces with germicidal soap, followed with chlorine rinse 25 parts per million (p.p.m.).

3. The stainless steel cans containing raw milk must be rinsed off with a 200 p.p.m. chlorine solution before being moved into the room.

4. Raw milk must be heated and prepared for cultures immediately after being brought into the laboratory.

Mother and intermediate culture operations are made in the plant every operating day. Many of these operations are carried on at the same time. For mother and intermediate cultures $1\frac{1}{2}$ gallons of raw whole milk are canned-off into each of eight stainless steel 10-gallon cans from one of the raw milk storage tanks (7, 8, and 9) and taken to the laboratory for preparation of culture. These cans must be sanitized with chlorine before being used. They must be hosed down with water and then fogged with a 1,000 p.p.m. chlorine solution before they can be taken into the culture area. Only the laboratory technician should be permitted to take cans into this area.

When the cans are in the culture room, four of them are set in the sterilizing vat consigned to culture for cultured milk and four are set in the sterilizing vat consigned to culture for cheese. Immediately 600 milliliters (ml.) of milk are dipped with a stainless steel graduate from a can into each of 12 mother culture bottles. An agitator is then placed in each can and a parchment sheet is placed over the top of the can before the lid is closed. The agitators are left in the cans with the milk and sterilized. Before placing the agitators in the cans of milk, the technician should dip his hands in a chlorine solution.

Each of the 12 bottles of mother culture is closed with parchment, followed by a bottle cap, and finally with foil. Then a 6- x 6-inch parchment is placed over the foil and held in place at the neck with a rubber band. Six bottles are placed in each vat.

Cleaned culture pipettes are placed in two one-quart bottles. The bottles are covered with foil and a parchment sheet held in place with a rubber band. Indicating thermometers are placed into two empty bottles which are left uncovered. A bottle with pipettes and a bottle with a thermometer are placed in each vat.

The vats are then filled with water to the overflow pipe; the steam is turned on; and the vat lids are closed. The water is heated to 195° F. and held at this temperature for 1 hour and 15 minutes. The operator then closes the steam valves and opens the well water valves gradually to bring the water temperature in the culture vat for cultured milk to 72° F. and the temperature in the culture vats for cheese to 70°. After 2 to 3 hours of cooling, the temperature of the milk in the cans should be the same as that of the water in the vats. The thermometer in each vat is used to check the temperature of the agitated sterile milk in the cans to be sure that the desired temperatures are obtained.

Before transferring chilled mother culture to the bottles of sterile milk, the room is fogged down and the tabletop is rinsed with 200 p.p.m. chlorine solution. Bottles of chilled mother culture in the coldroom and bottles of sterilized milk in the vats that are to be inoculated are brought to the transfer table and lined up. The curd of the mother culture in the bottle, from which the transfer is to be taken, is broken by shaking the bottle. The ease with which the curd breaks is indicative of the character of the culture. The top of the bottle containing mother culture from which the transfer is to be made and the top of the bottle of sterilized milk to be inoculated are loosened by grasping the edge of the inner parchment and carefully folding it back. From 5 to 6 ml. of mother culture are drawn with a sterile culture pipette from the culture bottle and deposited into the bottle containing sterilized milk. The speed of the flow of the culture from the pipette is an aid in evaluating the culture. The culture adhering to the pipette is tasted and evaluated for flavor.

The bottle of freshly inoculated milk is closed as previously described and identified with the culture number and date. The bottle is agitated by shaking gently and then placed in the water bath in the cheese culture vat. All bottles of sterilized milk are similarly inoculated and six bottles are placed in the cheese culture vat and six are placed in the cultured milk culture vat.

Each can with sterilized milk is inoculated while in the vats with 300 ml. of mother culture. The culture used for the inoculation is selected as the best on the basis of body and quality. The culture is poured into the can directly from the mother culture bottle, using the edge opposite to that opened for transferring. The contents of the can are then stirred with the hand agitator for 1 minute, after which the lid with parchment is replaced and the culture is ready for incubation.

After inoculation, each of the old mother cultures is titrated for lactic acid, and these data along with other information regarding each culture are recorded on a culture record form. The old mother cultures are then returned to the refrigerator and saved as insurance to be used if some accident occurs to prevent incubation from reaching the desired completion. Pipettes are then cleaned and rinsed; they are left in the incubation room to be sterilized the next day. All spilled milk or culture is cleaned up, and the floor and transfer area are rinsed with a 200 p.p.m. chlorine solution. The room, with temperature control set at 71° F., is kept closed for 12 hours.

After 12 hours, the temperature in the cheese culture vat is checked and the reading is recorded. The mother bottles are then lifted from the bath and slowly tipped to observe the degree of coagulation. If they show proper firmness, the mother cultures are promptly chilled in ice water in the refrigeration room. If they appear thin, they are held until the proper viscosity develops.

From each can in the cheese culture vat, a sample is taken with a sterile dipper for an acidity test. A developed acidity of 0.83 to 0.85 percent is considered proper for the intermediate culture. If the contents in all cans have developed sufficient acid, the water is removed from the vat and replaced with sweet water to arrest the growth of acid. After the contents have cooled for 1 hour, the cans are gently agitated. When the contents have cooled to 40° F., a sample is taken and tested for activity, gas fermentation, and coliform. The results of these tests determine whether these cultures can be safely used to inoculate the bulk culture. If the results are satisfactory, the cans are moved to the refrigerator room.

The same care and procedure is followed with the bottles and cans of inoculated milk in the cultured milk culture vat except that tests are done after an incubation period of 16 hours.

Suitable records should be maintained to detect early decline in a mother culture. Many off-flavored cultured milk preparations could have been avoided by simply observing the change in character of the culture. Likewise, an initial onset of a bacteriophage, infection may be indicated by a slow incubation, low acidity, weak body, or off-flavor in a mother culture.

Making Bulk Culture

Bulk culture is prepared in three 800-gallon culture vats (22, 22A, and 22B) located in the bulk culture room on the first floor. The bulk culture room is near the laboratory, the pasteurizing room, and the mother and intermediate culture room. The room is tiled and provided with filtered air ventilation.

Although only two vats are needed, a third will help to assure that at least two bulk cultures will be available for any day of cheese setting. This "insurance vat" will be available in the event that the other vats produce a bulk culture with a low acidity, a gas-producing set, or a slow-acid producer. In practice, therefore, two good cultures ordinarily will be available for each set. The one not used, if good, will be saved for the following day, and in the meantime a new bulk culture can be prepared in the third vat. No culture is wasted unless it is undesirable for cheese setting.

The first pasteurized skim milk obtained from HTST system (16) on the days that bulk culture is to be made is directed to the vat or vats to be used. The pasteurized skim milk is heated to 190° F. and held at that temperature in the vats for 1 hour. After 1 hour, the skim milk is cooled to 72° F. and is ready to be inoculated with intermediate culture.

An electrically operated hoist is suggested for handling the cans of intermediate culture used for the inoculation. Before inoculation, the bulk culture room should be fogged down with a 1,000 p.p.m. chlorine solution. Air entry from the cheesemaking area and the whey storage area can be avoided by maintaining filtered air under slight pressure in the room.

The skim milk is then inoculated with 0.75 to 1 percent intermediate culture and agitated for 15 minutes. The agitator is shut off; the water is removed from the vat jacket; and the steam bleeder valve is opened. The temperature of the room is maintained at 72° F., and the bulk culture is permitted to incubate.

After incubating for 12 hours or when the acidity (calculated as lactic acid) develops to 0.82 percent, the bulk culture coagulum is broken and tests are made for activity and gas formation. Assuming the results are satisfactory, the bulk culture is cooled to below 40° F. by sweet water. The bulk culture is now ready for use and may be refrigerated and held for as long as 3 days before being used.

In practice, bulk culture setting and scheduling proceeds as follows: Beginning Sunday midnight, vats (22) and (22B) would each contain 800 gallons of chilled culture pretested for activity and gas fermentation. Assuming that both vats are approved for cheese setting, one vat is used for Monday morning's cheese sets and the other for Tuesday morning's. Should one vat prove unusable, a fresh bulk culture would be prepared in vat (22A) early Monday morning for the Tuesday set. In addition, for extra insurance for the Tuesday set, a second fresh culture can be prepared Monday morning in the vat containing the rejected culture produced Saturday. If the cultures in vats (22) and (22B), available Sunday midnight, are acceptable for cheese setting, then a fresh culture is prepared on Tuesday morning for each of the 800-gallon vats (22 and 22A). The culture in these vats is broken, chilled, tested for activity and gas and is then ready for use Thursday morning. Assuming both vats are acceptable for cheese setting, the cheese sets for Thursday and Friday are assured.

If one of the bulk cultures is unusable for cheese setting on Thursday, then the same procedure for setting additional culture for Thursday would be followed as described for Monday morning.

If bulk culture vats (22) and (22A) are acceptable for cheese setting on Thursday, a fresh bulk culture is prepared Thursday morning in vat (22B). This vat is tested for cheese setting Friday morning. If satisfactory, it is held for Saturday's cheese set. If unacceptable, then vat (22) or (22A) is prepared Friday morning for Saturday's set.

Thus no day of cheese set is planned without an insurance culture potential and never without a pretested bulk culture at least 1 day before use. If the pretesting of the bulk culture indicates low activity or gas-producing tendency, a fresh bulk culture can still be prepared.

Finally, to complete the week, vats (22) and (22A) are prepared for fresh culture Saturday morning, and the culture in the vats is broken and chilled by 7:30 p.m. Saturday and pretested for Monday's cheese set.

Having three 800-gallon culture vats to supply actually only five vats of bulk culture during the week may seem wasteful in equipment and space. But, by having the third vat, valuable time will be saved in man-hours expended as the result of slow sets (failure to develop acidity at a satisfactory rate) or even losses in the cheese vats. The equivalent of a loss of one day's set of cheese, the overtime required to recoup sales inventory of product, and original product loss will go a long way toward paying for one extra bulk culture vat.

The 800-gallon culture vats are set about 5:30 a.m. The culture coagulum is broken at 5:30 p.m. When it is chilled to 40° F. (by 7:30 p.m.), the agitation and sweetwater circulation are cut off. The chilled product now holds safely until needed. Thus on Saturday and Tuesday the skim milk in two 800-gallon culture vats is pasteurized, cooled to 72°, inoculated, incubated, the curd broken, and chilled to 40° by 7:30 p.m. On Sunday and Wednesday no activity or scheduling is required on the 800-gallon culture vats since they function only as storage for chilled culture.

The first line of defense against the problem of slow sets in making bulk culture is alertness toward the initial onset of difficulty. This responsibility rests mainly with the laboratory workers. Preventive methods involve good sanitary procedures and controlled air movement within the various sections of the plant. Basically, the three principal reasons for slow sets are (a) antibiotics in the milk supply, (b) bacteriophage contamination, and (c) inadequate care of cultures.

Antibiotics in raw milk are responsible for a minor part of culture failures. The control of this problem rests with laboratory and the laboratory fieldmen. All raw milk from individual producers should be tested for inhibitory substances at least once a month and, if necessary, more often. The fieldmen must follow up any positive results to see that corrective measures are taken.

Bacteriophage contamination presents a different problem and is responsible for many slow sets. It cannot be as readily detected as antibiotics. This virus type of infection is present in almost every plant, but it becomes a problem only when the degree of infection becomes excessive. Here, preventive procedures provide the best plan of action. The following precautionary measures should be practiced at all times.

1. Under no circumstances should air, equipment, clothing, or individuals enter the culture area after having had contact with the cheese-cooking room.

2. All air surrounding mother, intermediate, and bulk cultures should be filtered and under positive pressure.

3. Extreme care and diligent attention to culture changes—forewarning bacteriophage contamination—must be provided by the laboratory.

4. An insurance bulk culture should be held in reserve. Different intermediate cultures should be used to inoculate the insurance bulk culture and the culture scheduled for use on this date. This procedure provides a safeguard

against complete reliance on one intermediate culture.

5. The pasteurized skim milk should be preset in completely closed vats to provide some protection against airborne infection carried from whey contact areas.

Good culture care is closely related to bacteriophage precaution. However, the need still remains to follow prescribed procedures to maintain balance of strains and active strains. The cheese culture must set at 72° F., and adhere closely to 12 hours of incubation. The amount of inoculation required to secure complete incubation within this time and temperature will vary from 0.75 to 1 percent. Complete incubation shall be considered as an acidity development of 0.90 to 0.95 percent, calculated as lactic acid, in the mother culture after it has been chilled to below 40° F. and after transfer to a new mother. If the acidity at this point is consistently below 0.90 percent, the culture will not maintain activity, flavor, or balance of strains. For example, a mother culture carried routinely below 0.90-percent acidity could show good characteristics through an intermediate and bulk transfer but with the next generation required from the bulk culture in the cheese set the activity may completely disappear, and the entire set be lost.

On the other hand, mother cultures consecutively carried to a chilled acidity above 0.95 percent will lose their balance of strains and will drift toward predominant excessive activity and acidity, followed by a complete fadeout of the entire culture. This sudden fadeout can occur in one generation. Should this generation be the actual cheese set, a slow set or a complete loss will result.

The so-called fast set, or a 90° F. cheese set (used in this operation), places a greater burden on culture care than does a low cheese set temperature (72°).

The same rigid application to details applies to the culture carried for cultured milk and cream. Here, although the same procedures are used, emphasis must be given to flavor and body. Each mother culture should be very carefully screened for these characteristics. The same acidity requirements must be observed in the chilled mother culture.

Gas production due to culture flavor organisms in cultured milk and cream is helpful for development of carbonation flavor. In cheese cultures, however, this would be very undesirable. Of course, gassiness due to coliform, yeast, or other types of contamination is objectionable in either mother culture system and its presence indicates a carelessly handled culture.

Manufacturing Small Curd (Country-Style) Cottage Cheese

The procedures given here for making cottage cheese are limited to the small curd country-style cottage cheese. Plants desiring to make large curd cheese would need to use slightly different procedures. The main problems in cottage cheese manufacture are (1) obtaining proper yield of curd, (2) avoiding slow sets and starter failures, (3) avoiding shattering of the curd, (4) producing a cheese of good keeping quality, and (5) obtaining high productivity per man-hour of labor.

To shorten the time cheese vats will be in use, a two-set schedule is followed. Each day the manufacture for the first setting would start about 1 a.m. and the second setting about 7 a.m. To do this, a closed storage tank (21, 21A, 21B, or 21C) is desirable in which to incubate the pasteurized skim milk through the lag phase of culture growth until a lactic acid titration value of about 0.3 percent is reached. This system not only provides fuller utilization of the cheese vats but assures complete agitation and mixing of skim milk, culture, calcium chloride, and rennet. It also provides some protection against bacteriophage contamination since this phase of the incubation takes place in a closed tank. Furthermore, the system eliminates the need for a "setter" commonly used with current methods, thus reducing labor costs.

The pasteurized skim milk to be used for making cottage cheese leaves the HTST system (16) at 90° F. and is transferred by measure-flow pump (17) directly to the 2,400-gallon preset vats (21, 21A, 21B, and 21C) which are equipped with load cells. Bulk culture and a calcium chloride solution are metered under pressure into the lines feeding skim milk to the preset vats by the culture metering pump (25) and the calcium chloride metering pump (24). Culture is added at the rate of about 4 percent of the volume of skim milk—about 1,450 pounds per hour and the calcium chloride solution is added at the rate of 7 gallons per hour.

At the control panel (92) the "Culture From" selector switch controls the outlet valve on the culture vats. Selection of the vat, plus actuating the culture metering pump (25) opens the valve and starts this process. Calcium chloride is metered into a preset vat (21, 21A, or 21B) by pressing the button for the calcium chloride metering pump (24).

The skim milk, culture, and calcium chloride are continuously agitated in the preset tanks until the acidity, calculated as lactic acid, develops to about 0.30 percent. If a severe incidence of bacteriophage infection occurs and the acid fails to develop, the skim milk is pumped (pump 27) into the whey storage tank (30) and would probably be used for animal feed. Pump (107) is used to move the whey into a tank truck. If the acidity development is normal, required amounts of rennet are added manually to the preset mixture through the pour inlet located to the front and on top of the vat. The agitation is continued another 15 minutes. Then the mixture is pumped (pump 102) into the 1,200-gallon cheese vats (26, 26A-G). A record should be kept of the weights of the mixture pumped into each cheese vat. This weight is provided on a digital readout on the panel.

Two 1,200-gallon cheese vats are set at one time from a 2,400-gallon preset vat. Since the preset mixture has culture fermentation in progress and is properly mixed, all or any part of the 2,400 gallons will continue the same rate of acid development if held at 90° F. Hence, the slight difference in time of dropping the preset mixture in the first and second vat will not alter the subsequent rate of fermentation in either of the two.

To empty a preset vat, the proper vat is selected on the "Preset Empty" switch on control panel (92). This connects the "Preset Cut-Off" digital indicator to the proper vat. The amount of product to be removed is subtracted from the amount in the preset vat, and this quantity is set on the preset cut-off digital indicator by a perimeter knob. The cheese vat to which the preset is to be directed is set on the "Cheese Vat Fill" switch. Actuating the pushbutton for pump (102) alines the air-operated valves properly and pumps the preset to the selected cheese vat (26, 26A-G). When the predetermined amount has been delivered to the cheese vat, the pump (102) shuts off and the valves close.

When the mixture coagulum in the cheese vats attains a pH of 4.7, the curd is cut by manually drawing curd knives of the proper size through the coagulum. The size of the curd particle for country-style cheese is $^1/_4$ by $^1/_4$ inch.

The vats now contain cubes of curd which immediately begin to diffuse whey from within. At this point, the curd is left undisturbed for 30 minutes to permit "healing" of the cubes, which results in a strengthening of the surfaces.

Meanwhile, the vat is connected to the external whey heater (28) which has a return line connecting to a sanitized distribution pipe that is submerged in the middle of the vat, running the length.

After a 30-minute healing period, the cooking process is started. The whey pump (27) is started and the whey is circulated from the vat through the heater and back into the vat. The temperature of the whey is 90° F. when cooking begins. It is circulated through the heater for 30 minutes at temperatures ranging from 95° to 98°, for 30 minutes at 105° to 108° and for 30 minutes at 125°. The last temperature may be varied from 118° to 130° depending on the curd characteristics, which vary with the milk and with the season of the year. The healing and cooking period requires about 2 hours.

The manner and frequency of agitation during cooking should be the minimum necessary to secure good distribution of heat and to prevent the curd from matting. Generally, after the first 30 minutes of cooking, the curd is gently moved about 12 inches away from the sides of the vat toward the center with a stainless steel paddle. Fifteen minutes later the procedure is repeated by moving the curd to the center of the vat. Fifteen to 20 minutes later the procedure is again repeated. Thereafter, as needed, the paddle is used to lift the curd from the sides toward the top center. The important point is to secure good heat distribution with the minimum of curd breakdown or curd matting.

The method of cooking curd by circulating whey through an external heater has several advantages: (1) Less steam is required; (2) less agitation is required; (3) less expensive vat structure is required since the jacket and the water circulating systems within the jackets and the overhead mechanical agitators are unnecessary; (4) greater uniformity in size of curd is attained; and (5) less heat is radiated in the vicinity of the cheese vats, making it more comfortable for the cheesemakers.

When the final cookout has been attained, the whey is rapidly pumped (pump 27) from the vat into the whey storage vat (30), and 90° F. wash water is added in an amount equal to the whey removed. The wash water is moved by pump (95) from the wash water filter and treating unit (96) through the cooler (63) to the insulated storage tank (29) and then to the cheese vat. Following equilibration of curd and water temperature, the wash water is rapidly removed. The second water is added at 60°, mixed completely with the curd, held 10 minutes, and rapidly drained. The final washing is done with 34° water. Here, again, the curd and water are equilibrated in temperature, which requires holding for about 10 minutes.

The curd and final rinse water are dropped by gravity through the outlet valve to the draining and creaming vats (31 and 31A), which are mounted on load cells. The water is rapidly drained from the curd, and the curd weight is recorded. The required amount of cottage cheese dressing is then pumped (pump 44) to the vat from the cheese dressing tank (43). (See preparation of cottage cheese dressing.)

Since it is assumed that the creamed curd is to contain 5-percent fat and since the dressing contains 15-percent fat, 100 pounds of dressing is required for each 200 pounds of curd.

Cottage cheese dressing is prepared by mixing whole milk and cream in the desired proportions in one of the 3,000-gallon weigh tanks (4, 5) immediately before pasteurization of skim milk ends for the first cheese set. Salt, nonfat milk solids, and stabilizer are added by a funnel and circulating pump (84) in such proportions that the mixture tests 15-percent fat, 2.8-percent salt, 0.25-percent gum stabilizer, and 8-percent milk solids-not-fat. As soon as the skim milk has cleared the HTST unit (16) these products are pumped to the pasteurizer, bypassing the clarifier and separator. They are then homogenized (18) and pumped to the cottage cheese dressing storage tank (43).

Weights of the draining and creaming vats (31, 31A) are shown on the digital indicators which are connected to load cells on these vats. By adding the proper weight for the cheese dressing to the weight of curd and adjusting the perimeter knob of the digital indicator for this amount, the cheese dressing may be added automatically to the curd. The "Dressing Discharge" selector switch is set on the draining and creaming vat to which the cheese dressing is to be added, and "Pump 44" is actuated. This switch alines the air-operated valves and starts the pump (44). When the proper amount of cheese dressing has been added, as determined by the load cells, the pump shuts off and the air-operated valves close automatically.

The mixture of curd and dressing is then pumped (32) into one of the blenders (33), where the dressing is uniformly mixed with the curd and the cheese acquires the desired luster.

The time required to manufacture a batch of cheese and move it into the blending vat is about 6 hours, beginning at 1 a.m. and ending at 7 a.m.

Blending and mixing curd and cheese dressing for the first batch would begin about 9 a.m. and end about noon—for the second batch, from 3 p.m. to about 5:30 p.m. Packaging would begin and end about the same time as the blending curd and cheese dressing. The first batch of cottage cheese would be packaged in 12- and 16-ounce cartons using packaging machines (34, 34A-B) with a capacity of 25 to 100 containers per minute. The second batch would be packaged in 16-ounce cartons using these machines (34, 34A-B) and in 50-pound bags using the bulk packaging machine (35).

As 12- and 16-ounce cartons are filled, they are conveyed to the automatic cottage cheese cup-box former and caser (36). This machine automatically forms fiberboard boxes and places 24 of the 12- or 16-ounce cartons in the boxes. The boxes are then conveyed from the caser to the cold storage room where they are manually removed from the conveyor and stacked on pallets. Sixty-six boxes of 12-ounce cartons or 50 boxes of 16-ounce cartons would be stacked on a pallet. The 50-pound bags are conveyed directly from the packaging machine (35) to the storage room where they are manually removed and stacked on pallets, 36 bags per pallet.

Manufacturing Cream Cheese

The old established and commonly used method for the manufacture of cream cheese involved the culturing of a pasteurized 15- to 18-percent butterfat cream in 4-gallon cans. Upon completion of incubation, the coagulum was agitated and cooked (heated to 120° to 125° F.) by placing the cans in hot water. The mixture was then placed in muslin-draining bags which were pressed, chilled, stacked, and restacked to facilitate expulsion of whey. Finally, the drained curd was packaged.

Obviously, from the standpoint of sanitation and efficiency, this is a questionable procedure for modern, large-scale operations. A much improved method of separating the curd and whey using centrifugal force has been developed. However, this procedure is patented and is not available for cream mixtures having a butterfat content ranging from 5 to 29 percent.

A similar machine is available which uses a base mix up to 5-percent butterfat. A description of this machine and the patented process used to make cream cheese follow.

In manufacturing cream cheese, cream is pumped from the cream storage tank (42) and the whole milk used for standardizing is pumped from one of the weighing tanks (4 or 5) into one of the vacuum pressure vats for cultured milk (48, 48A, or 48B). Switches "Transfer From" and "Cream From" on control panel (92) (fig. 4) are set to the desired vat, the "Vat Receive" switch set to the desired vat, and the pushbutton activated. In this vat the base mix is standardized to slightly under 5 percent butterfat.

The base mix is vat pasteurized at 170° F. for 30 minutes. Following pasteurization, the mix is cooled by pumping well water into the jacket of the vat and agitating it. As soon as the temperature of the mix drops to 100°, the well water is replaced with sweet water for further cooling. These operations are all done automatically by setting the vat switch to positions indicated on the dials for vats (48, 48A, and 48B) (fig. 3). When the temperature of the mix reaches 70°, it is inoculated with bulk culture in amounts up to 0.75 percent of the base mix.

The product then sets for about 16 hours to allow the acid fermentation to develop to 0.83 to 0.87 percent. The coagulum is then broken and the product is cooled to about 65° F. Cooling is done by starting the agitator and pumping sweet water through the jacket.

The outlet valve of the vat is then connected to positive displacement pump (52). The mix is pumped through a steam injector (59) to raise its temperature to 120° F. and through the curd concentrator (53).

Concentrated mix and whey are discharged from the curd concentrator to the cream cheese processing kettles (54, 54A). The concentrated mix has a composition of approximately 26-percent milk solids-not-fat and 17-percent butterfat. The whey contains approximately 6- to 6.5-percent solids, which consists largely of lactose, albumen, and globulin.

In the 200-gallon processing kettles (54, 54A) cream, milk solids-not-fat, salt, and stabilizer are added to standardize the product to a 35-percent butterfat, 1-percent salt, 0.25-percent locust bean gum, and 45-percent (minimum) total solids cream cheese mixture.

The mixture is heated to 150° F. in the vat by hot water and pumped (pump 55) through the 125-gallon per hour homogenizer (56), the pressure-relief valve (57), and to the packaging machine (58).

The vacuum pressure vat operation would begin about 12 noon and would end about 8 a.m. the following day when making 6,000 pounds of cream cheese. The curd concentrator operation, heating kettle operation, and homogenizing and packaging operations would begin shortly after 8 a.m. and continue until about 3:40 p.m. when packaging is completed. Cream cheese would be packaged in 3- and 8-ounce packages. Three-ounce packages would be packaged at the rate of 50 per minute and 8-ounce packages at the rate of 35 per minute.

As 3- and 8-ounce packages are filled, they are placed manually in fiberboard boxes. Six packages of each size are placed in a box, and 24 boxes of the small size and 12 of the large are placed in a large pack. These packs are placed on pallets, 90 per pallet of the 3-ounce size and 50 per pallet of the 12-ounce size. A forklift truck moves the pallets into the storage room.

Making Cultured Milk

Skim milk and whole milk are blended together to a finished composition of 1-percent butterfat in making cultured milk. Skim milk is pumped directly from the HTST system (16) into one of the vacuum pressure vats of cultured milk (48, 48A, or 48B). The required amount of skim milk is determined by the measure flow pump (10). Whole milk used in standardizing is pumped (pump 6) from one of the storage tanks (7, 8, or 9) into one of the weighing tanks (4 or 5) and from the weighing tank into the vat which contains the skim milk. This transfer of milk is accomplished by setting the indicators on the selected tanks and activating the pump on the control panel (92).

The standardized product is pasteurized (control panel 94) in the vat by heating it to 190° F. and holding it at that temperature for 30 minutes to an hour. The temperatures and time of holding will be varied from season to season to compensate for viscosity differences due to changes in milk composition. After holding for the desired time, the product is cooled to 70° by circulating city water and sweet water in the jacket. It is held at this temperature for inoculation (0.75 to 1 percent of base mix) with bulk culture and incubation.

During the process of heating, holding, cooling, and inoculation, the swept surface agitator in the vat is operating to provide good distribution of temperature and adequate mixing of the culture. The agitation is stopped 15 minutes after the addition of the culture or after assurance that the 70° F. temperature has been reached.

All water is removed from the vat jacket; all valves are tightly closed; and the steam bleeder valve is opened. The vat is not disturbed, except to check the temperature, until 16 hours of incubation are completed or until the acidity, calculated as lactic acid, is 0.88 percent. This acidity is determined from a laboratory analysis of a sample of the coagulum.

The product curd is then broken and the cultured milk is cooled. The agitator is turned on at fast speed for 5 minutes, and simultaneously sweet water is circulated throughout the jacket. Rapid agitation is essential to attain a smooth product free of lumps or undisturbed coagulum areas. After 5 minutes the agitator is turned to low speed and continues at this speed until the cultured milk cools to 40° F. If desired, salt may be added at the rate of 15 pounds per 1,000 gallons after cooling.

The cultured milk is now ready for packaging in quart and half-pint containers by the paper carton filling machine (50). About 24,500 containers of each size are needed. After the containers are filled, they are conveyed to the caser and packed automatically in cases. Sixteen bottles of the quart size and 32 of the half-pint size are packed per case. These cases are then conveyed to the coldroom, removed from the conveyor, and placed on pallets—36 cases per pallet. A forklift truck moves the pallets to storage points in the coldroom.

Making Cultured Cream

Whole milk and 40-percent cream are blended together to a finished composition of 18-percent butterfat for cultured (sour) cream in one of the weighing tanks (4 or 5). Cream for standardizing would be pumped (pump 45) from the cream storage tank (42) into the weigh tank containing whole milk. Whole milk is pumped into the weigh tank (4 or 5) from storage tank (7, 8, or 9).

From the weigh tank the product is pumped (pump 10) through the HTST unit (16) at 161° F., held for 15 seconds, homogenized at 800-pounds pressure, cooled to 70°, and then pumped into one of the 1,000-gallon vacuum pressure vats of cultured cream (46, 46A, or 46B). These tanks are constructed so that they can be pressurized to help force the flow of heavy cream to the filler. In the vat, the product is heated to 160° for 30 minutes. The second heating, accomplished from the control panel (94), produces a better body in the cream. After the cream cools to 70°, it is inoculated with bulk culture in an amount equal to 0.50 to 0.75 percent of the total product.

All the water in the jacket of the vat is then removed and all the valves except the steam bleeder valve, are tightly closed. The steam bleeder valve is opened so that any steam that might leak by the steam inlet valve can escape. This prevents the temperature of the cream from creeping up and assures a minimum of error through temperature changes during incubation. The vat is left completely undisturbed, except to check the temperature, until about 16 hours of incubation are completed, or when the acidity attains the desired 0.60 percent. Varying the percentage of inoculation provides a means of controlling the incubation time of 16 hours.

The product curd is broken and the coagulum is cooled to 65° F. by circulating sweet water in the jacket of the vat. At this stage, packaging may begin by turning air pressure into the vat to assist the gravity flow, thereby pushing the cultured cream into one of the packaging machines (34, 34A, 34B).

Each packaging machine has a special nozzle to break up clumps of cream before packaging. This nozzle consists of a plate with $^1/_4$-inch openings through which the cream is pushed. The cultured cream is packaged in 8-ounce cartons and packed 24 cartons per box in fiberboard cases. These cases are then moved into the 35° F. coldroom for final cooling.

Cleaning Equipment

Before the dairy manufacturing industry was automated, an estimated 40 to 50 percent of the plant labor was utilized in washing and sanitizing the equipment. Not only was this work time consuming and tedious, but it was not done properly many times. Since the use of chemicals was not carefully controlled, most workers used more than was needed, resulting in much waste. The workers thought the chemicals would reduce the amount of handscrubbing.

Circulation methods of cleaning closed systems, such as plate heat exchangers and sanitary pipelines through which milk and milk products flowed, were introduced into this country from Europe following World War II. The results were so favorable that dairy technologists and public health sanitarians working together began to improve these early methods. These efforts led to the development of CIP (cleaned-in-place) methods involving permanent pipelines and fittings and spraying devices for large vats and milk delivery trucks. At first, such methods were manually operated and then, almost simultaneously with the development of dairy plant automation, the cleaning and sanitizing processes were brought under automatic control. An operator can clean and sanitize much of the equipment in the plant with a central control. Some equipment, however, cannot be cleaned satisfactorily in this way, such as clarifiers, separators, homogenizers, some pumps, open vats (such as cottage cheese vats), some valves, fittings, and other small items of equipment.

In closed circuits, such as heat exchangers, the CIP circulating unit can force the cleaning and sanitizing solution through the entire system and back into the solution tank. But where the circuit cannot be put under pressure the entire distance, as in a milk truck tank or a storage vat, the CIP circulating pump delivers the cleaning or sanitizing solution to a spray ball system mounted in the vat or tank, and a separate pump returns the solution to the CIP unit for recirculation.

Two CIP systems are used in this plant (fig. 11). System 61A is a two-tank compartment unit using a hot alkali cleaning solution on truck tanks, weigh tanks (4, 5), the raw milk cooler (3), and the raw milk cold storage tanks (7, 8, 9).

System 61, a three-tank compartment unit using both alkali and acid solutions, is used on all equipment having surfaces that come in contact with the hot milk, such as the HTST pasteurizing system (16). It can be used on equipment that comes in contact with only cold milk by omitting the acid wash cycle.

All the storage tanks have built-in spray balls that give sufficient hydraulic action to clean the soiled surfaces.

The units (61 and 61A) come completely assembled. Individual program punchcards are used to prevent mixup in the cleaning cycle. The unit is 41 inches wide and 61 inches long and stands 74 inches high. Each stainless steel tank has a maximum working capacity of 165 gallons. The flow of solutions to and from the unit is regulated by air-actuated valves. The unit includes a temperature control device, a level control, a recorder, air blowdown, and cleaning cycle unit with electropneumatic punchcard program selector for each type of cleaning requirement.

The automatic CIP units clean and sanitize the surfaces of milk processing equipment that come in contact with the product without dismantling by controlling the circulation of cleaning and sterilizing agents. The temperature and elapsed time for each phase of the cleaning cycle is automatically controlled. A CIP recorder-controlling instrument keeps a record of the cleaning procedure for review by management and health regulatory agencies. The time, temperature, and pressure of the cleaning, rinsing, and sterilizing solutions are recorded here.

Coupled with the recorder-controller is an electropneumatic punchcard program selector. This device automatically sets the elapsed time, circulating temperature, and proper valve sequencing for whatever item of equipment is to be cleaned. To clean an item of equipment, the proper punchcard is selected from the card file and inserted into the program selector. The program may be changed by making up a new punchcard. Once the program is established, however, it does not need to be changed unless some factors, such as the cleaning compounds, are changed.

Valve sequencing is necessary to insure proper cleaning of valve parts as well as branch lines. The program controller sets the valves in the proper position for cleaning and also sequences the proper valves to clean branch lines.

The "Off-On" pushbutton turns on the power to the control system. The "Start" button initiates the program selected by the punchcard. The "Stop" button shuts off the program at any point the operator wishes; the program may be again picked up by pushing the Start button. If the operator should desire to start the program from the beginning, the "Reset" button is pushed, followed by the Start button.

To clean the various closed top tanks and vats, a swing elbow connection must be made at CIP hookup station (80) which connects the spray balls to the CIP solution lines. To make this connection the cap covering the solution line must be unlocked. The key for the cap is located under the manhole. This procedure insures that the tank is properly vented to prevent collapse from vacuum during the final cold water rinse.

Pipelines are cleaned by making hose-jumper connections to complete circuits, followed by circulation of the solutions and valve sequencing by the automatic CIP units.

The following equipment would be manually cleaned by conventional take-down or hand-brush methods: Measure flow pumps (10, 17), clarifier (11), separator (13), homogenizer (18), positive pump (39), filler hoppers, valves, and bowls on fillers (34, 50, 58), culture meter pump (25), cheese vats (26, 26A-G), draining and creaming vats (31, 31A), cream cheese equipment (52, 53, 54, 55, 56) and its interconnecting piping, cottage cheese sanitary lines between cheese vats (26, 26A-G), and fillers (34, 34A-B). All other equipment would be cleaned in place.

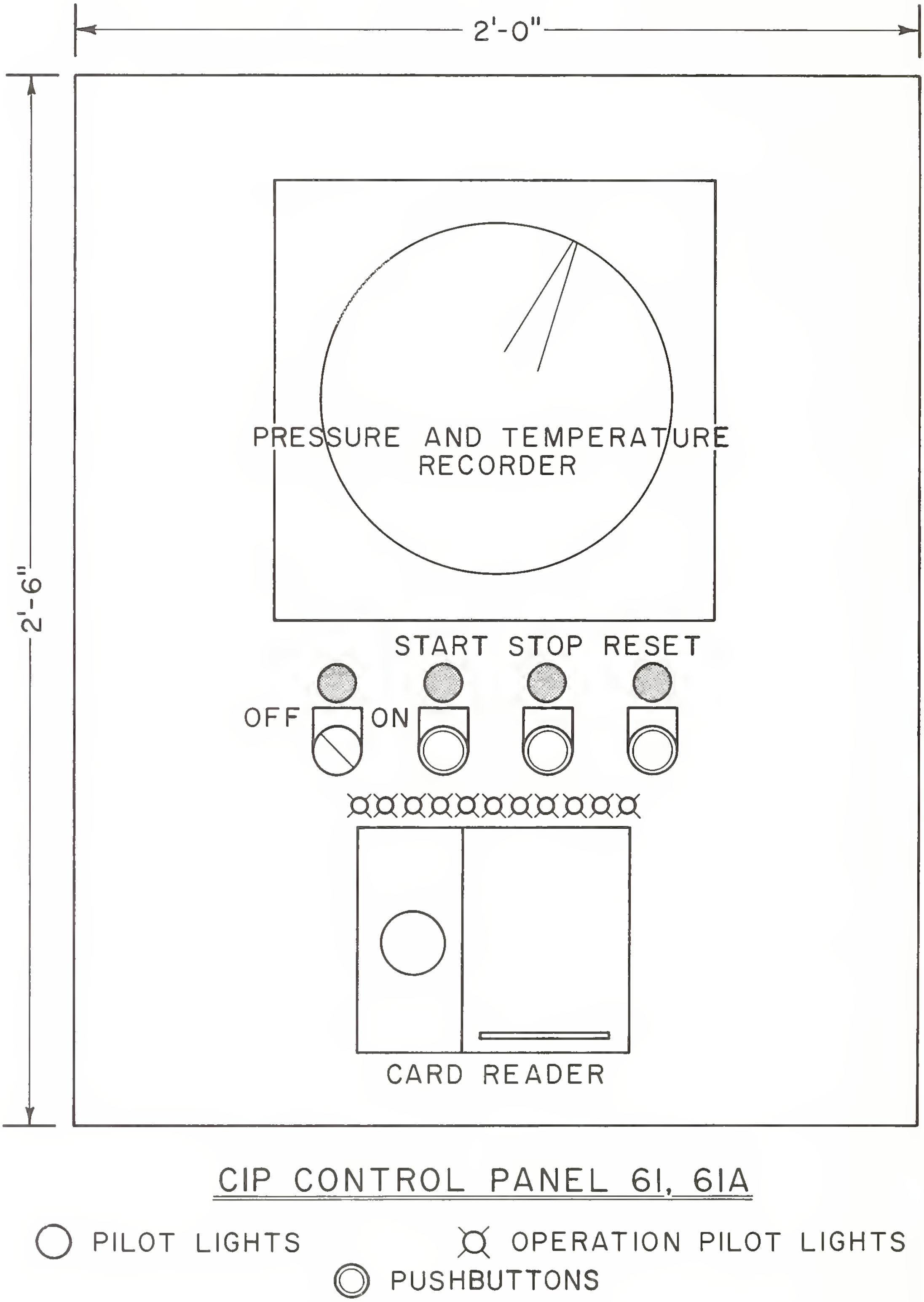


FIGURE 11.—A suggested control panel for programing and controlling the CIP cleaning operations.

CIP Cleaning of Cold Surfaces Using Control Panel 61A

To initiate the cleaning cycle for any storage tank, tank truck, set of milk lines, or processing equipment, the punched card for the cleaning operation for the respective item is inserted into the cycle-sequencing unit, and the operation is set into motion by pushing the proper button. A sample procedure follows for the closed circuit cleaning of storage tanks.

Prerinse:

1. Rinse tank automatically filled.
2. Temperature control set initially approximately 100° F.
3. Burst rinse and discharge to drain until clear.
4. Return to rinse tank when clear; circulate 5 minutes.

Alkali wash:

1. Solution tank automatically filled.
2. Alkali washing powder added to solution tank by operator.
3. Initial time period set approximately 40 minutes.
4. Temperature control set initially approximately 140° F.
5. Circulate at adjusted temperature and time period, discharging back to solution tank.
6. Cycle ends with all solution returned to solution tank.

Rinse:

1. Rinse tank full from last prerinse return.
2. Rinse, temperature same as prerinse, for 5 minutes.
3. Circulate tap temperature water for 10 minutes and return to rinse tank.

Sanitize (just before using):

1. Insert card for sanitizing program.
2. Sanitize chemical powder added to rinse tank by operator.
3. Circulate cold rinse water for required period advised by sanitizer manufacturer, which is programed on card.
4. Discharge to drain.

CIP Cleaning of Hot Surfaces Using Control Panel 61

Control panel 61, a three-tank compartment unit, is used to clean surfaces that come in contact with the hot milk. It uses both alkali and acid solutions. The procedure is as follows:

Prerinse:

1. Rinse tank automatically filled.
2. Temperature control set initially approximately 100° F.
3. Rinse through lines and discharge to drain until clear.
4. Return to rinse tank when clear; circulate 5 minutes.

Alkali wash:

1. Solution tank automatically filled.
2. Alkali wash powder added to solution tank by operator.
3. Initial time period set approximately 30 minutes.
4. Temperature control set initially approximately 165° F.
5. Circulate at adjusted temperature and time period, discharging back to solution tank.
6. Cycle ends with all solution returned into solution tank.

Rinse:

1. Rinse tank full from last prerinse return.
2. Rinse at 165° F. for 2 minutes maximum; discharge to drain.

Acid wash:

1. Solution tank automatically filled.
2. Acid cleaner added to solution tank by operator.
3. Initial time period set approximately 20 minutes.
4. Temperature control set initially approximately 165° F.
5. Circulate at adjusted temperature and time period, discharging back to solution tank.

Rinse:

1. Rinse tank full from last prerinse return.

2. Rinse same temperature as prerinse for 5 minutes; discharge to drain.

3. Circulate rinse tap temperature water for 10 minutes; return to rinse tank.

Sanitize (just before using):

1. Insert card for sanitizing program.

2. Sanitize chemical powder added to rinse tank by operator.

3. Circulate cold rinse water for required period advised by sanitizer manufacturer, which is programed on card.

4. Discharge to drain.

Cleaning Out of Place (COP)

Some take-down sanitary pipes and certain pieces of equipment, such as positive displacement pumps, separators, clarifiers, homogenizers, curd knives, strainers, dippers and pails, need to be cleaned out of place. The machines are taken apart and rinsed free of heavy milk remnants, and the various parts and other loose items of equipment are placed in a small tank (78) made especially for COP operations.

The stainless steel tank is 20 inches wide, 18 inches deep, and 74 inches long. It has a capacity of 100 gallons. The jet-controlled flow circulation system assures thorough scrubbing of any shaped piece placed in the tank. A circulating pump is mounted beneath the tank. A two-way valve in the pump discharge line permits recirculation of cleaning or sanitizing solution, or discharge to the floor. After the parts are rinsed with 100° F. water, cleaning and sanitizing solutions are recirculated through the tank in the same way as in the CIP system. The type and strength of the cleaner used will need to be varied according to the degree of soiling.

Auxiliary equipment needed with the COP tank includes a small parts basket, separator discs rack, sanitary fittings rack, separator and clarifier truck, and crane truck for hoisting heavy bowls from separator and clarifier frame. The tanks and some auxiliary items are mounted on casters so that they can be moved where they are needed.

Manual Cleaning and Sanitizing

The exteriors of all large items of equipment must be kept free of soil. Hosing with warm water by the operator while or after the equipment is used is usually sufficient.

Some of the large items of equipment must be hand washed, such as cheese vats (26, 26A-G), balance tanks (14, 37), draining and creaming vats (31, 31A), curd and cream dressing blenders (33, 33A), cream cheese processing kettles (54, 54A), and the cultured milk filling machine (50).

To prepare the curd and cream dressing blenders for cleaning, an electric hoist removes the agitator and nylon bushings from the bowl. The procedure for cleaning these items of equipment is as follows:

1. Rinse with warm (100° F.) water as soon as possible after use.

2. Scrape milk deposits or cheese solids from surface of vat, using a limber plastic blade or nylon curd scraper, taking precaution to prevent scratching the polished surfaces.

3. Prepare concentrated washing solution in plastic pail, using 4 ounces of chlorinated alkali detergent to each gallon of 125° F. water.

4. Spread solution on sides, bottom, and outlet valve with nylon brush. With rest of solution, scrub-wash sides of vat, bottom, and outlet. A short soaking period will loosen the soil and make the cleaning task easier.

5. Rinse vat thoroughly with a hose using clear 100° F. water.

Every 3 or 4 days vary the procedure by using an ounce of organic acid compound to each gallon of 125° F. water. Repeat rinsing procedure.

Before using equipment, spray or fog with 500 p.p.m. available chlorine solution for sanitizing.

To clean the cheese cooking kettles, thoroughly flush with clean 100° F. water after shutdown. Refill cooker with 125° water. Add 3 pounds chlorinated alkaline cleaner. Heat to 140° and let soak 30 minutes. Brush all surfaces, and drain to floor. Flush with clean, cold water.

Once each week after cleaning with alkaline compound, rewash coookers with an organic cleaning solution, using 5-ounces cleaning solution to 10 gallons water. This procedure will prevent the formation of milk or water stone on the surfaces.

The following cleaning procedure should be followed in cleaning the machine used for filling plastic-coated containers with cultured milk:

1. Turn off power before cleaning as a safety precaution.
2. Rinse filler bowl and assembly with 100° F. water immediately after use.
3. Dismantle tank, filler assembly, and accessories. Wash thoroughly with stiff bristle brush and chlorinated alkaline detergent solution (2 ounces per gallon of 130° F. water). Rinse with 100° F. water.
4. Scrub mandrels, mandrel hub, bottom pressure pad, tucker, breaker, defoamer, top heating unit (when cool), sealing unit, and conveyor chains with 125° F. wetting agent solution (1 ounce per gallon). Avoid getting solution into air holes in end of mandrels.
5. Scrub inner and outer surfaces of machine frame with the wetting agent solution.
6. Rinse all washed parts with 100° F. water, keeping splash and spray to a minimum.
7. Lubricate machine.
8. Before production resumes, sanitize milk tank, filling machine and lines with chlorine solution of 100 p.p.m. Hold float down to allow sanitizing solution to overflow tank, and with filler valves tripped, start machine and operate for 3 minutes to allow solution to sanitize all surfaces that some in contact with milk.
9. Fog inside and outside surfaces of machine from feeder to discharge section with a noncorrosive 400 p.p.m. sanitizing solution.

Loading Out

Deliveries are made in refrigerated trailer trucks. Generally, one or more trucks are loaded each day. Each truck is loaded with various products according to the specific orders of the buyers.

A forklift truck hauls the pallets of products from the cold storage room into the trailer trucks. Often the pallets are hauled directly to the trucks from the packaging area, bypassing the coldroom.

As all the delivery trucks are refrigerated, they can be used as auxiliary coldrooms. Each truck has a capacity of 18 pallets.

LABOR REQUIREMENTS

Twenty-three workers, including two supervisors, are used in the receiving, processing, and packaging operations. With the exception of worker No. 16, they work on Monday, Tuesday, Thursday, Friday, and Saturday. No. 16 works on Sunday, Tuesday, Wednesday, Friday, and Saturday.

Except for worker No. 20, who starts at midnight, the work week begins at 1 a.m. Monday. Each worker is assigned specific duties and specific hours. The supervisors are responsible for making out the work schedules, including one-half hour lunch periods, and seeing that each worker reports for duty at the time assigned.

At 1 a.m., the amount of raw milk in storage (tanks 7, 8, and 9) varies with the day of the week, as shown in table 1. Usually, two of the 800-gallon vats (22, 22A, 22B) are filled with approved bulk culture ready for use. All laboratory tests on these cultures will have been completed and the rate of inoculation determined. All equipment will have been reassembled ready to be sanitized.

The workers and duties of each assigned to receiving and processing operations are as follows:

Worker No. 1 (Processor-cleaner):

1:00 a.m.—9:30 a.m.

1:00 Sanitizes all equipment automatically through which milk flows from raw storage tank to culture vats (22, 22A, 22B) and preset vats (21, 21A, 21B, 21C) including clarifier (11), separator (13), and HTST units (16, 38). Starts raw milk through system, directing the first skim milk to the empty culture vat (22, 22A, 22B).

1:30 Directs first pasteurized skim milk into the preset vats (21, 21A, 21B, 21C) together with the required amounts of culture and calcium chloride, which are metered into the line. Prepared cheese dressing by directing cream and raw whole milk into one of the weigh tanks (4, 5) and adding predetermined amounts of dry milk solids and salts. Pumps these products into pasteurizer (16) through the homogenizer (18) and into cheese dressing storage tank (43) when skim milk has cleared the HTST unit (16).

3:30 Drops first preset skim milk into cheese vats 1 and 2 (26).

4:00 Cleans and sanitizes clarifier, separator, HTST unit, and preset vats. Reassemble clarifier and separator for second setting of cheese.

7:00 Pasteurizes skim milk for second cheese set.

9:15 Cleans and sanitizes raw storage tanks (7, 8, and 9).

Worker No. 2 (Processor-cleaner):
9:00 a.m.—5:30 p.m.

Drops first of second set of preset skim milk into the cheese vats (26, 26A–G) and completes duties associated with preset of second cheese set. Does the final cleaning of clarifier, separator, HTST units (opens HTST unit for inspection), and associated sanitary pipeline assembly. Helps clean all empty raw storage tanks (7, 8, 9) and weigh tanks (4, 5). Maintains floor and walls in this area.

Tuesday and Saturday only: Pasteurizes skim milk needed for cultured milk.

Monday, Thursday, Friday only: Standardizes, pasteurizes, and homogenizes cultured cream and pumps to the multiprocess tanks all scheduled cultured products.

Worker No. 3 (Laboratory technician):
1:00 a.m.—9:30 a.m.

All technical phase of operation, such as:

1. Pasteurizes, holds, cools, and sets bulk culture.
2. Determines acid development of skim milk in preset vats.
3. Decides when to drop preset milk to cheese vats.
4. Initiates daily preparation of mother and intermediate culture routine.
5. Records all weights with control panel. Determines all necessary laboratory tests and standardization procedures.
6. Conducts all quality tests pertinent to product.
7. Initiates bulk composite milk sample duties as milk delivery tank trucks arrive.

Worker No. 4 (Laboratory technician):
9:30 a.m.—6:00 p.m.

1. Completes bulk milk composite sample distribution.
2. Continues daily filling and package room checks.
3. Runs bacterial tests of plant products, containers, and raw milk supplies.
4. Continues work started by worker No. 3.

Worker No. 5 (Receiver):
4:30 a.m.—1:00 p.m.

Receives all deliveries of bulk tank trucks. This involves initial sanitizing of equipment, unloading, rinsing, and cleaning all bulk tanks.

Works closely with the laboratory on weights and collection of samples of butterfat from each pooled bulk delivery and each agitated raw storage tank. Maintains floor and walls in the receiving area and cleans pumps, sanitary pipelines, and the raw milk plate cooler (3) after use. Assists worker No. 2 in cleaning and maintaining the raw storage tanks (7, 8, and 9) and weigh tanks (4, 5).

Worker No. 6 (General processor and creamer):

3:30 a.m.—12:00 m.

Assembles and sanitizes lines from the preset vats (21) to cheese vats (26); lines from multiprocess vats to the respective fillers (34, 50); all processing equipment associated with cream cheese processing such as curd concentrator (52), pumps (53), homogenizer (56), and kettles (54); lines for circulating whey to heater and return, including whey heater (28); and lines from cheese vats to draining and creaming vats (31). Sanitizes cheese vats (26), draining and creaming vats (31), and blender (33). Helps clean all preset vats (21) and multiprocess vats (46, 48), as emptied. Pasteurizes, holds, cools, and inoculates all cultured milk, cream, or cream cheese mix base scheduled during his work period. Checks progress of cheese vat coagulation and acid development and, when needed, assists worker No. 8 in cutting and cooking cheese. Responsible for creaming and mixing the finished cottage cheese. Upon direction from the laboratory, he breaks the cultured cream and cheese mix base by turning on the agitators in the multiprocess vats (46; 46A,B; 48; 48A,B).

Worker No. 7 (General processor and creamer):

11:00 a.m.—7:30 p.m.

Completes cream cheese mix base concentration and processing, creaming of cottage cheese, and pasteurizing-holding-cooling and inoculation of cultured milk, cream, or cream cheese mix base, and completes cleaning of preset and multiprocess vats. Responsible for final cleaning of cream cheese processing equipment and the creaming and blending vats and assists worker No. 11 in all cleaning of processing equipment. Maintains the floors and walls in his area.

Worker No. 8 (First cooker):

5:00 a.m.—1:30 p.m.

Assemblies and sanitizes all equipment connected with cooking the curd. Responsible for pH measurements to determine when the curd is ready to be cut. Assists in the cutting and directs the cooking and creaming of the curd.

Worker No. 9 (Second cooker):

7:00 a.m.—3:30 p.m.

Assists in cutting, cooking, whey draining, adding cooling water, cleaning and sanitizing cheese vats, and the creaming of the curd.

Worker No. 10 (Third cooker):

8:00 a.m.—4:30 p.m.

Assists in cutting, cooking, whey draining, adding of cooling water, creaming of curd, and in cleaning and sanitizing vats before the second set. Also assists in cooking, cooling, and creaming the second set.

Worker No. 11 (Fourth cooker):

11:00 a.m.—7:30 p.m.

Assists in all phases of cooking, draining, creaming, and cleanup. Duties include the final cleanup of all equipment and the floors and walls in the cheese manufacturing area.

Workers Nos. 12, 13, 14, and 15 (Packaging crew):

Duties are described under Packaging Room Work Schedule.

Work No. 16 (Receiver and packager):

4:30 a.m.—1:00 p.m. Sunday and Wednesday

Receives bulk milk on these days. Also breaks cultured milk curd when it is ready, as indicated by the acidity test, and cools the product on these 2 days.

6:00 a.m.—2:30 p.m. Tuesday, Friday, and Saturday

Packages cream cheese.

Worker No. 17 (Stockroom man):

4:30 a.m.—1:00 p.m.

Brings all paper and bottling supplies to the packaging area, removes empty cartons and damaged bottles to incinerator, unloads all supply trucks, maintains supplies for the laboratory and other plant areas, and maintains orderliness in dry storage room. Responsible for ordering all supplies. There are no truck deliveries after noon.

Worker No. 18 (Coldroom man No. 1.):

4:30 a.m.—1:00 p.m.

Loads out products into trucks stacking corrugated containers in the cooler on pallets, maintains product inventory, and maintains an orderly cooler area.

Worker No. 19 (Coldroom man No. 2.):

10:00 a.m.—6:30 p.m.

Duties complement those of worker No. 18; in addition, handles bulk packages of cottage cheese. Locks all cold storage room doors when he leaves.

Worker No. 20. (Maintenance man No. 1.):

12:00 p.m.—8:30 a.m.

Starts automatic gas boiler, maintains refrigeration system, pumps, and other equipment and takes care of all breakdowns while he is on duty.

Worker No. 21 (Maintenance man No. 2.):

8:30 a.m.—5:00 p.m.

Responsibilities are same as those of worker No. 20.

Worker No. 22 (General supervisor):

1:00 a.m.—9:30 a.m.

Synchronizes all operations and plans work schedules for entire operation.

Worker No. 23 (Assistant general supervisor):

9:30 a.m.—5:00 p.m.

Sees that packaging room is supplied with containers and executes work plans laid out by supervisor.

The work schedule and duty assignments for the packaging workers depend on what items are to be packaged each day and the number of each item. The schedule is based on the peak volume.

In each working day of the peak volume week, 43,950 pounds of cottage cheese are to be packaged. Of this amount, 13,186 pounds are to be packaged in 100-pound bags and 15,382 pounds each into 12- and 16-ounce cups. Packaging time will be about 4 hours.

On Tuesday, Friday, and Saturday, 20,000 pounds of cultured cream are to be packaged into 8-ounce cups. Packaging time will be about 3 hours.

On Monday and Thursday, 7,670 gallons of cultured milk are to be packaged, 6,140 gallons in quart containers and 1,530 gallons in half-pints. This operation will take about 11 hours.

On Tuesday, Friday, and Saturday, 18,000 gallons of cream cheese are packaged. This volume is divided equally between 3- and 8-ounce cups.

Surplus cream is stored in tank (106). On Monday, Tuesday, Thursday, and Saturday, this cream is pumped into a bulk tank truck and delivered to an ice cream plant. Workers No. 12, 13, 14, or 15 perform this operation.

Five workers (Nos. 12, 13, 14, 15, and 16) are assigned to the packaging work. The workers will shift from packaging one product to another as needed. The schedules for Monday and Tuesday are given in detail. The plant is closed on Wednesday and Sunday. Thursday's operation is a repeat of Monday; Friday and Saturday repeat Tuesday's schedule. Workers 12, 13, 14, and 15 are scheduled for Monday, Tuesday, Thursday, Friday, and Saturday. Worker 16 is assigned to the packaging operation on Tuesday, Friday, and Saturday.

Schedule for Monday's Packaging Operations

A. Cultured milk

Workers 12 and 13 assigned to this operation which starts at 4:30 a.m. and ends at 1:00 p.m.

4:30 a.m.—Sanitize lines and machines.
5:00 a.m.—Starts bottling quarts.
10:00 a.m.—Finish bottling quarts.
10:10 a.m.—Start bottling half-pints.
3:10 p.m.—Finish bottling half-pints.
5:00 p.m.—Machine washed and serviced.

Workers 12 and 13 start the operation. After the filling machine (50) and the automatic caser (51) are adjusted so that they work smoothly, No. 12 remains in charge while No. 13 assembles and sanitizes the cheese packaging machine (34) and lines. At 7:45 a.m., the packaging machine is ready for use and No. 13 eats lunch. At 8:15 he relieves No. 12 so that he can have lunch. At 9 a.m., No. 13 shifts to the cheese packaging operation.

Workers 12 and 13 clock out at 1:00 p.m.

B. Cottage cheese

Workers 13, 14, and 15 are assigned to this operation, which starts at 9:00 a.m. and finishes at 5:30 p.m.

9:00 a.m.—No. 13 starts filling 12-oz. packages with one machine (34).
10:00 a.m.—Workers 14 and 15 clock in, and start operating the other two machines.
11:00 a.m.—Finish filling 12-oz packages.
11:15 a.m.—Start filling 16-oz packages.
12:00 noon—Finish 16-oz. packages, completing the packaging of the first cheese set.
12:15 p.m.—Cheese lines, cheese blending vat, and cheese packaging machines cleaned by Nos. 13, 14, 15.
1:00 p.m.—Worker No. 13 clocks out. No. 14 shifts to packaging cultured milk, and No. 15 completes cleaning and sanitizing the cheese lines, blending vat, and packaging machines.
1:45 p.m.—No. 15 eats lunch.
2:15 p.m.—No. 15 relieves No. 14 for lunch.
2:45 p.m.—No. 14 returns from lunch.
3:00 p.m.—No. 15 starts packaging machine on the cottage cheese from the second set, filling 16-oz packages.
3:10 p.m.—No. 14 returns to the cheese packaging area. Both men together run one packaging machine and fill 50-lb. bulk units in polyethylene bags inside fiberboard boxes.
5:30 p.m.—Last of second setting of cottage cheese is packaged. Nos. 14 and 15 wash cheese packaging and cultured milk bottling machines.
6:30 p.m.—Workers 14 and 15 clock out.

Schedule for Tuesday's Packaging Operations

A. Cultured cream

Workers 12 and 13 are assigned to this operation, which starts at 4:30 a.m. and finishes at 8:00 a.m.

4:30 a.m.—Sanitize lines and machines.
5:00 a.m.—Start three machines (34, 34A, 34B) for packaging cultured cream (same machines used for cottage cheese).
8:00 a.m.—Packaging completed. Both workers eat lunch.
8:30 a.m.—Lines and machines are washed and sanitized.
9:15 a.m.—Washing and sanitizing completed.

B. Cottage cheese

Workers 12, 13, 14, and 15 are assigned to this operation, which starts at 9:15 a.m. and ends at 5:30 p.m.

9:15 a.m.—All three machines (34, 34A, 34B) are started on 12-oz. packages by workers 12 and 13.
10:00 a.m.—Workers 14 and 15 clock in; No. 12 transfers to cream cheese packaging.
11:00 a.m.—Finish filling 12-oz. packages.
11:15 a.m.—Start filling 16-oz. packages.
12:00 noon—Finish filling 16-oz. packages, which completes the pack-

aging of cottage cheese from first set.

12:15 p.m.—Wash and sanitize lines and machines.

1:00 p.m.—Workers 12 and 13 clock out; workers 14 and 15 shift to packaging cream cheese.

1:45 p.m.—No. 15 eats lunch.

2:15 p.m.—No. 15 relieves No. 14 for lunch.

2:45 p.m.—No. 14 returns from lunch.

3:00 p.m.—Worker 15 starts one machine (34) to package cottage cheese from the second set.

3:30 p.m.—Workers 14 and 15 together package 50-lb. bulk cartons of cottage cheese.

5:30 p.m.—Finish packaging cottage cheese from second set; clean equipment.

6:30 p.m.—Workers 14 and 15 clock out.

C. Cream cheese

Workers 12, 13, 14, 15, and 16 are assigned to this operation, which starts at 4:30 a.m. and finishes at 2:45 p.m.

4:30 a.m.—Nos. 12 and 13 sanitize packaging equipment (58); at same time they sanitize the cultured cream packaging equipment (34).

6:00 a.m.—Worker 16 clocks in and starts packaging 8-oz. units of cream cheese.

9:00 a.m.—Complete packaging 8-oz. units.

9:15 a.m.—Start packaging 3-oz. units.

10:00 a.m.—Worker 12 reports in from cottage cheese operation.

11:00 a.m.—Worker 16 eats lunch.

1:00 p.m.—Worker 12 clocks out and workers 14 and 15 report in from cottage cheese operation.

1:45 p.m.—Worker 15 eats lunch.

2:15 p.m.—Work 14 eats lunch.

2:30 p.m.—Worker 16 clocks out.

2:45 p.m.—Cream cheese packaging completed; Nos. 14 and 15 clean equipment.

3:00 p.m.—Worker 15 returns to packaging cottage cheese.

3:30 p.m.—Work 14 returns to packaging cottage cheese.

COSTS AND POSSIBLE BENEFITS OF LABOR-SAVING DEVICES

The equipment required for the automated plant to minimize labor requirements would consist of:

Four COP tanks
Two CIP tanks and controls
Two curd draining and creaming vats
Two cheese blending vats
One curd concentrator
Two pallet trucks
One cream cheese filling and wrapping machine.
One cheese cooker
Thirty air-actuated valves
Twenty-two load cells
Two measure-flow pumps
One automatic caser
One automatic box former and sealer
Extra pipelines and valves
Three panel boards and controls

The cottage cheese filling machine and cultured milk filling machines would be needed even if the plant were not automated, so their cost is not included. The estimated cost of the equipment needed to automate the plant is $255,000.

To operate the automated plant, 23 workers and supervisors are required. If the operations in this plant were not automated, an additional 19 workers would be needed, as follows:

1. Two men to clean truck tanks, weighing vats, plate cooler, raw storage tanks, HTST unit, separator, and clarifier, and to take down and clean sanitary pipelines.

2. One man to clean multiprocess vats, preset vats, cream vats, and cheese dressing vats.

3. Three men to shovel curd from vats to cans and to move cans to mixers.
4. Two men to bag, ice, turn, press, empty cream cheese bags, and dump cultured cream into filler.
5. One man to wash cheese cans needed for curd mixing machine and shipping curd, and for washing milk cans for shipping surplus cream and multiservice cases for cultured milk.
6. Three men for packaging product from cheese filling machines and cultured milk filling machine.
7. Two men to load trucks when pallets are not used and to stack packaged items in cold storage room.
8. Three more men in cheese-setting area when preset system is not used.
9. One additional laboratory man when preset system is not used.
10. One additional man to move supplies from storeroom to packaging area and to move packaged items into cold storage room.

Assuming that the average wage cost (including fringe benefits) of each worker is $6,500 annually, annual savings in labor would amount to $123,500. The cost of the mechanized and automated equipment needed to make this saving possible is estimated at $255,000. If 20 percent is charged against this amount for ownership and operating costs (depreciation, maintenance, insurance, taxes, and interest), the annual cost would be $51,000 and annual savings $72,500.

Since five different products are handled in this plant—cultured milk, cultured cream, cottage cheese, cream cheese, and surplus cream—productivity per man-hour can be best determined on the basis of total pounds or gallons of milk handled per hour of labor. With an expected peak amount of 1,200,000 pounds of milk handled per week, the automated plant, which employs 23 workers for 40 hours per week, would have a production per man-hour of 1,304 pounds, or 152 gallons. The nonautomated plant of the same size would have a production per man-hour of 715 pounds, or 83 gallons.

In addition to the greater hourly productivity of labor in the automated plant, yields of cheese would be greater as in-plant product loss would be reduced. More efficient use of chemicals and better cleaning and sanitizing that would be possible using CIP methods would add further to the economic advantages of automation.

APPENDIX: REFRIGERATING, HEATING, VENTILATING, AND AIR CONDITIONING

Refrigeration System

The refrigeration system for this plant should be adequate for cooling milk and milk products and maintaining the required coldroom temperature. Milk and milk products would be cooled by sweet water from an ice builder circulating through insulated jackets in tanks or vats adjacent to the products, or in plate-heat exchanger. An ice builder is a refrigerant evaporator coil immersed in a tank of water. A reserve of ice is built up during slack periods of refrigeration to provide an adequate source of refrigeration when needed. Tap water enters the tank, circulates around the ice-covered coils until cold, and then leaves the tank. Cooling milk with an ice builder is frequently called "cooling with sweet water."

The coldroom would be refrigerated by six direct expansion cooling units. Each unit has coils in which ammonia evaporates, cooling them. Air is blown over these coils by a fan in the unit, thereby cooling the room.

The refrigeration calculations are based partly on data contained in the "Mechanical Engineers' Handbook" (pp. 79, 303, and 2154), "Heating, Ventilating and Air Conditioning Guide" (p. 254), and "Refrigeration Engineering Application Data." [4]

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[4] MARKS, LIONEL S. MECHANICAL ENGINEERS' HANDBOOK. 4th ed., illus. 1941; AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS. HEATING AND VENTILATING AND AIR CONDITIONING GUIDE. 1947; SEGAL, S. CHARLES. REFRIGERATION LOAD CALCULATIONS—II. TEMPERATURES BELOW 32°—REFRIG. ENGIN. APPLIC. DATA 12. Refrig. Engin. vol. 39, No. 4, sec. 2. April 1940.

Refrigeration requirements used in determining the sizes of equipment suggested for the plant are described below. These requirements are offered only as a guide, since many conditions, such as temperature differences, types of building materials used, and equipment arrangement, affect the requirements of a particular plant. Operators who are planning to build new plants or to remodel their present ones should consult local refrigeration engineers for their requirements.

Milk Cooling Requirements

The milk cooling load would be based on the plant's peak volume day. The plant's production under these conditions has been listed previously for Tuesday and Saturday.

The cooling load on the ice builder may be determined by dividing the daily B.t.u. (British thermal units) requirements for each load by the latent heat of fusion of ice, which is 144 B.t.u. per pound. For example, the specific heat of milk is 1.0, the figure ordinarily used by industry in determining the size needed for refrigeration equipment. The actual specific heat for milk, skim milk, and similar low-fat products is 0.93. For 40-percent cream, the specific heat is 0.85 and for 20-percent cream, 0.90. One ton of refrigeration equals 12,000 B.t.u.

The formula for daily B.t.u. requirements is—

B.t.u. per day (24 hours) = Weight of product × Temperature change × Specific heat

Equipment number	Product	Amount of product	Temperature change	Specific heat	Requirements per day
		Pounds	*° F.*		*B.t.u.*
3	Raw milk cooling	172,000	42 – 36	1.00	1,032,000
38	Cream in HTST	24,100	105 – 38	.85	1,372,495
16	Cheese dressing	14,650	66 – 38	.90	369,180
16	Skim to bulk culture	12,400	90 – 38	1.00	644,800
16	Skim to cultured milk	49,500	90 – 38	1.00	2,574,000
46	Cultured cream (20 pct.)	20,000	70 – 65	.90	90,000
48	Cultured milk	66,000	100 – 70	1.00	1,980,000
	Total ice builder				8,062,475
	Plus 10 pct. line and agitation loses				806,247
	Total requirements				8,868,722

$$\text{Pounds ice required} = \frac{8{,}868{,}722}{144} = 61{,}588$$

A 62,000-pound ice builder (62) is suggested. The size of the compressor required to build 62,000 pounds of ice in 16 hours would be—

$$\frac{62{,}000 \times 144}{12{,}000 \times 16} = 46.5 \text{ tons.}$$

To handle this load, a 47-ton, 75 hp. ammonia compressor (67) is suggested. It would operate at 25 pounds suction pressure and 185 pounds condensing pressure.

The cultured milk cooling load which occurs after the product is incubated has not been included in these calculations. The reason for this is that it occurs on Wednesday and Sunday when the plant is not operating, except for receiving milk, and the refrigeration load is light.

Some milk product cooling is also performed in coldwall storage tanks (42, 43, 106), although these tanks are primarily for holding rather than cooling milk. Manufacturers' tables indicate that 12 tons of refrigeration should be provided for these three tanks.

Cheese Wash Water Requirements

Each vat of cottage cheese requires 840 gallons of 34° F. chilled wash water, or for a maximum production of 16 vats on a peak day, 13,440 gallons. A 15,000-gallon insulated storage tank (29) is suggested to store this water. It is equipped with high- and low-level controls which automatically start and stop the flow of water through the water-treating system (96) and shell-and-tube water cooler (63), as well as starting and stopping the ammonia compressor (66) which provides the refrigeration. Since large amounts of wash water are required at the cheese vats in a short period of time, the 15,000-gallon storage tank (29) is used to even out the load over an 8-hour period. The 15,000-gallon tank will hold 124,500 pounds of water. If this water is admitted to the tank over an 8-hour period, the flow through the water cooler (63) would be about 15,600 pounds per hour. The refrigeration load would be—

$$\text{Refrigeration load} = \frac{\begin{array}{c}\text{Pounds water}\\ \text{cooled per}\\ \text{hour}\end{array} \times \begin{array}{c}\text{Temperature}\\ \text{change}\end{array} \times \begin{array}{c}\text{Specific}\\ \text{heat}\end{array}}{12{,}000 \text{ (B.t.u. per ton)}}$$

It is assumed that the peak water temperature in summer months would be 80° F. The specific heat of water is 1.0.

$$\text{Refrigeration load} = \frac{15{,}600 \times (80 - 34) \times 1.0}{12{,}000} = 59.8 \text{ tons}$$

To handle this load, a 61-ton, 75-hp. ammonia compressor (66) is suggested. It would operate at 40 pounds suction pressure and 185 pounds condensing pressure.

Coldroom Requirements

The refrigeration requirements of the coldroom are determined by (1) heat gain through walls, ceiling, and floor, (2) heat gain through air changes in the coldroom, (3) heat gain from electrical energy, and (4) heat gain from products held in the room. A heat gain would also be incurred from workers in the room. However, for the proposed plant this would be only one or two people, depending upon the packaging operation and the load-out situation at any particular time. Thus, the heat gain from workers would be comparatively small and is included in the suggested safety factor for the room.

To determine the peak average hourly load for the room, the peak average hourly load for each factor must be calculated. In these calculations the peak average hourly load is computed for all factors except the heat gain from product entering and being held in the room. Many products will not be stored in the room at all; they will pass through the room and be loaded directly onto delivery trucks. In addition, the different products enter at different rates and at different times. Therefore, on the product load the average of a 24-hour period is used.

(1) Heat gains through walls, ceiling, and floor are calculated by the formula shown below. The calculations are based on a coldroom temperature of 35° F. and an outside temperature of 95°. An average overall coefficient of heat transmission for walls, floor, and ceiling of 0.0756 B.t.u. per hour per square foot per degree Fahrenheit temperature difference is suggested. This is equivalent to a wall section of 8 inches of brick and 4 inches of insulation. The coldroom for the suggested plant would have a surface area of—

$$\begin{array}{llr}
\text{Walls} & = (21\text{x}17\text{x}2) + (25\text{x}12\text{x}2) & \\
 & \quad + (40\text{x}17) + (40\text{x}12) & = 3{,}494 \text{ sq. ft.}\\
\text{Ceiling} & = 76 \text{ x } 40 & = 3{,}040 \text{ sq. ft.}\\
\text{Floor} & = 76 \text{ x } 40 & = 3{,}040 \text{ sq. ft.}\\
\quad\text{Total Surface} & & = 9{,}574 \text{ sq. ft.}
\end{array}$$

$$\begin{array}{l}\text{Heat gain}\\ \text{through}\\ \text{walls,}\\ \text{floor, and}\\ \text{ceiling}\\ \text{(B.t.u./}\\ \text{hr.)}\end{array} = \begin{array}{c}\text{Surface}\\ \text{area}\\ \text{(sq. ft.)}\end{array} \times \begin{array}{c}0.0756\\ \text{B.t.u. per}\\ \text{hr. per}\\ \text{sq. ft.}\\ \text{per ° F.}\end{array} \times \begin{array}{c}\text{Tempera-}\\ \text{ture}\\ \text{change}\\ \text{(° F.)}\end{array}$$

$$= 9{,}574 \times 0.0756 \times 60 = 43{,}428 \text{ B.t.u./hr.}$$

(2) Heat gain from air changes is calculated by the following formula. A room of this type is estimated to have one air change every 2 hours, or 0.5 change per hour.

$$\begin{array}{l}\text{Heat gain}\\ \text{from air}\\ \text{changes}\\ \text{(B.t.u./}\\ \text{hr.)}\end{array} = \begin{array}{c}\text{Volume}\\ \text{of room}\\ \text{(cu. ft.)}\end{array} \times \begin{array}{c}2.53\\ \text{(B.t.u}\\ \text{per hr.}\\ \text{per cu.}\\ \text{ft.)}\end{array} \times \begin{array}{c}\text{Number}\\ \text{of air}\\ \text{changes}\\ \text{per hr.}\end{array}$$

$$= 38{,}380 \times 2.53 \times 0.5 = 48{,}550 \text{ B.t.u./hr.}$$

(3) Heat gain from electrical energy is from electrical motors and lights. It is assumed that the six cooling units use 3 hp., the conveyor motor, 2 hp., and forklift truck, 1 hp. per hour, or a total of 6 hp. from electric motors. For this calculation, one horsepower equals 3,700 B.t.u. per hour.

Heat gain from motors (B.t.u. per hr.) = Motor horsepower x 3,700
= 6 x 3,700
= 22,200 B.t.u. per hr.

It is assumed that 1,400 watts of electricity are used for lights; 1 watt-hour equals 3.42 B.t.u. per hour.

Heat gain from lights (B.t.u. per hr.) = No. watts x 3.42
= 1,400 x 3.42
= 4,788 B.t.u. per hr.

Total heat gain from electrical energy = 26,988 B.t.u. per hr.

Heat gain from product entering the room is calculated for Tuesday, a peak day. The refrigeration load is determined by assuming that the average blend temperature of product, product containers, and product cases will be as listed below, and that this temperature along with the specific heat factor results in an accurate estimate of the heat gain due to products entering the room.

The formula for determining the heat gain from products entering the room is:

$$\text{Heat gain from product (B.t.u. per hour)} = \frac{\text{Weight of product} \times \text{Temperature change} \times \text{Specific heat}}{24 \text{ (hours)}}$$

Product	Product weight	Temperature in	Temperature out	Specific heat	Heat gain per hour
	Pounds	°*F.*	°*F.*		*B.t.u.*
Cottage cheese	43,950	45	35	0.70	12,819
Cultured cream	20,000	65	35	.90	22,500
Cream cheese	6,000	150	35	.90	25,875
Total products					61,194

Summary of heat gains in the coldroom

	B.t.u. per hour
Walls, ceiling, floor	43,428
Air changes	48,550
Electrical energy	26,988
Product entering room	61,194
Total	180,160
10 percent allowance for safety factor	18,016
Total design requirement	198,176

Since the room cooling units (64, 64A–E) are to operate only 16 hours per day to provide 8 hours for automatic defrosting, this load (198,176) must be removed from the room in two-thirds of an hour. Therefore, the cooling unit must remove 198,176 × 3 ÷ 2, or 297,264 B.t.u. per hour.

The total refrigeration load would be:

$$\frac{297{,}264}{12{,}000} = 24.8 \text{ tons.}$$

The six cooling units (64, 64A–E) suggested have a capacity of 4.2 tons each, or a total of 25.2 tons. This load, added to the cold-wall tank load of 12 tons, totals 36.8 tons. A 36-ton, 40-hp. ammonia compressor (65) is suggested to handle this requirement. The size is adequate, as it is not anticipated that all the cold-wall tanks would require maximum refrigeration at the same time.

Condensing capacity for the three ammonia compressors is supplied by two 75-ton evaporative condensers located on the roof.

Additional equipment suggested in the refrigeration area includes a 20-inch by 20-foot ammonia receiver (69) and an electric distribution panel (90). A schematic diagram of the ammonia refrigeration system is shown in figure 12.

Automatic Refrigeration Controls

The cold storage room is controlled by a room thermostat which is set to turn on at 38° F. and off at 35°. This thermostat controls the solenoid valves which admit refrigerant to the cooling units (64, 64A–E), thus starting and stopping their refrigeration effect. When the refrigerant is off, the coils are pumped down and the air-circulation fan automatically defrosts them by circulating room air over the coils.

Ammonia compressor (65) is controlled by a capacity reduction which will unload one bank of two of four cylinders on the machine, thus giving a 50-percent reduction in capacity. A pressure switch on the machine controls this automatically. Thus, this unit will adjust itself to handle any fluctuation in load which occurs due to the variation in the refrigeration requirements of the cold-wall tank, as well as seasonal or time-of-day variations in the cold-room load. This compressor is interlocked electrically with the solenoid valves on the refrigerant inlets of the cold-wall tanks, so that should these tanks be on refrigeration, the compressor will not shut off. However, if the tanks are off, the room thermostat will shut the compressor off.

The solenoid valves on the cold-wall tanks (42, 43, 106) are controlled from control panel (94).

The ice builder is controlled by an automatic ice thickness control. This control automatically turns off the ammonia compressor (67) when the proper amount of ice is built up on the coils. At this time, the refrigerant inlet solenoid valve is closed and the suction line bypass opened to the line leading to the ammonia compressor (65), which will hold a 30° F. ammonia temperature in the coil by a back pressure regulator which is set at 45 pounds. This regulator aids in holding the ice on the coils. The ice builder is started manually by a plant worker. The ice builder should be checked at least once each day, making an automatic start-up unnecessary.

The cheese wash water tubular cooler (63) is controlled by a high-level probe in storage tank (29) to turn off the water supply, and a low-level probe, set at 10,000 gallons, which will turn on the water. These same probes start and stop ammonia compressor (66), which is also equipped with capacity controls to effect a one-third capacity reduction by a suction pressure switch. In localities having a wide variation in temperature of water during the change in seasons, the refrigeration effect and power requirements will be less during the winter months. The temperature of the water leaving the cooler is controlled closely because the ammonia temperature is maintained at a constant 29° F.; thus, for a fixed rate of water flow, there is little variation in the discharge temperature.

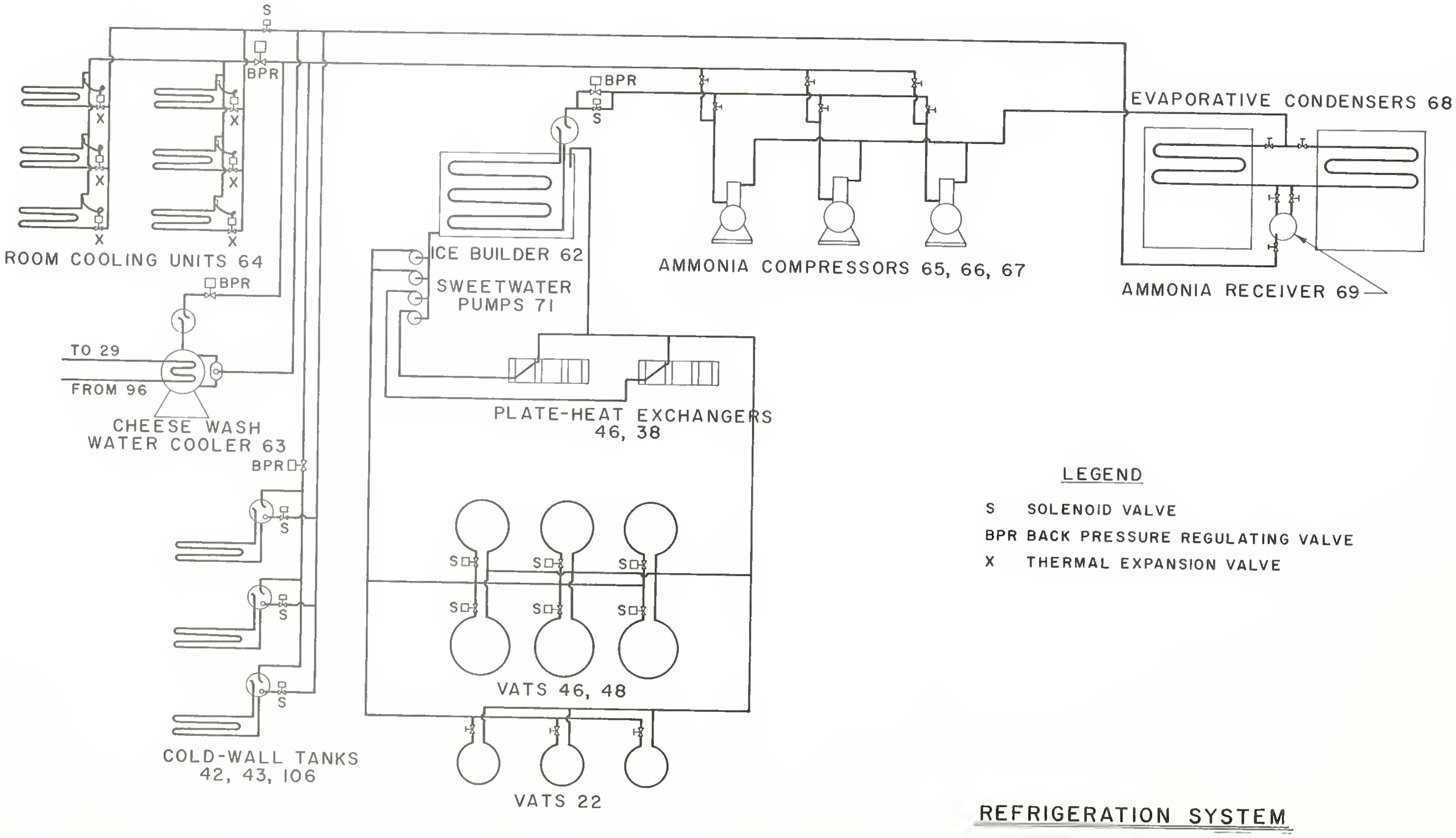
The condensing pressure is controlled by pressure switches which start the fan and pump motors on a rise in pressure. The first evaporative condenser fan would turn on at 150 p.s.i. and off at 135 p.s.i. The second evaporative condenser would turn on at 155 p.s.i. and off at 140. The pumps on the first and second evaporative condensers would be set to turn on at 160 and 165 p.s.i., respectively, and off at 145 and 150.

Heating, Ventilating, and Air Conditioning for the Plant

Several types of heating, ventilating, and air-conditioning units are suggested for the plant. Each has different features, which make it desirable for the particular application to which it is assigned.

Air-conditioning unit (97), suggested for the office area, is the standard type of unit commonly used in small office buildings.

Heating and ventilating units for the processing room (99), culture processing room (100), and cottage cheese processing room (100) provide for ventilation in summer and ventilation with heating in winter. Air is distributed into the room by ceiling ductwork, with return air picked up near the floor for return to the unit by ducts. The units are equipped with fresh air inlets and automatic dampers to control the ratio of fresh to circulated air. The air next passes through a filter to remove dust particles, then through the heating coil


ROOM COOLING UNITS 64
X
BPR
S
CHEESE WASH WATER COOLER 63
TO 29
FROM 96
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ICE BUILDER 62
SWEETWATER PUMPS 71
PLATE-HEAT EXCHANGERS 46, 38
VATS 46, 48
VATS 22
AMMONIA COMPRESSORS 65, 66, 67
EVAPORATIVE CONDENSERS 68
AMMONIA RECEIVER 69
LEGEND
S SOLENOID VALVE
BPR BACK PRESSURE REGULATING VALVE
X THERMAL EXPANSION VALVE
REFRIGERATION SYSTEM

FIGURE 12.—Refrigeration system for a dairy plant handling 1,200,000 pounds of whole milk weekly.

from where it is returned to the room. The unit maintains a slight positive pressure in the spaces serviced so that leakage of air is out of the building rather than into it. The temperature is controlled by a room thermostat. The circulating fan is two-speed. Slow speed is used for winter heating and high speed for summer ventilation or stepped-up ventilation during periods of cleanup with its consequent high humidity.

Air-conditioning and purifying units for the bulk culture room and laboratory (72), for the packaging room (73), and the transfer and incubation room (74) are basically the same as those described except for (1) additional air filtration, and (2) Freon refrigerated coil for summer air conditioning. Before the air is returned to the rooms, it passes through a high-efficiency filter which removes 99 percent or more of the dust-borne bacteria. This filtering is vital in the control of bacteriophage as well as in preventing contamination of cultured products from undesirable strains of organisms. Adjacent to the heating coil is a refrigeration coil for maintaining a comfortable operating temperature during the hot weather. Generally, 70° F. is maintained in these rooms, except for the packaging room, which is held at 65° to improve the keeping quality of the cultured products.

A separate air-conditioning and purifying unit (74) is suggested for the transfer and incubation rooms because of the necessity of absolute control over bacteria conditions in these areas. The use of an individual unit here eliminates the possibility of mother culture contamination through air circulation from another source in the plant.

Freon condensing units (75, 76, and 76A) are used to provide refrigeration on the air-conditioning and purifying units (72, 73, and 74). A conventional thermostat automatically turns on the refrigeration system when required.

Unit heaters (98, 98A) are suggested for space heating in winter in the tanker-receiving shelter and refrigeration equipment areas. These units are automatically controlled by thermostats.

The boiler room is heated by radiation from the boilers. Not shown, but required, are wall-type exhaust fans for the boiler, refrigeration, and tanker-receiving areas.

The lunchroom and locker room would be air conditioned in summer and heated in winter by wall-mounted heat pump units (not shown).

A heating system would be required for the plant to provide hot water and steam for heating milk and milk products, cleaning, and heating the building. A heating system for a plant should be adequate to handle its peak heating requirements. The requirements for a particular plant would depend to some extent on the climate of the area in which the plant is located. Thus, heating data provided herein are offered as a guide only. Operators planning to build new plants or remodel their present ones should contact local heating engineers for their heating requirements.

The formula for determining the B.t.u. requirements for heating milk products is:

$$\begin{array}{c}\text{B.t.u.}\\ \text{per hour}\end{array} = \begin{array}{c}\text{Pounds of}\\ \text{milk per}\\ \text{hour}\end{array} \times \begin{array}{c}\text{Tem-}\\ \text{perature}\\ \text{change}\end{array} \times \begin{array}{c}\text{Specific}\\ \text{heat}\end{array}$$

Since all product heating is done by steam, the total B.t.u. requirements may be converted to pounds of steam per hour and to boiler horsepower.

Tabulated below are the B.t.u. requirements for heating various milk products in the plant, based on this formula. No more than two of the 2,000-gallon vats (48, 48A, B) or two of the 1,000-gallon vats (46, 46A, B) would be heated at the same time. The vats would heat through the temperature range indicated in 45 minutes; therefore, the B.t.u. requirements per hour are adjusted to include this.

Equipment number	Product	Amount of product per hour (pounds)	Temperature change (° F.)	Specific heat	B.t.u. per hour
12	Milk preheating	40,000	36 – 90	1.0	2,1600,000
16	Skim milk HTST	36,200	151 – 162	1.0	398,200
38	Cream HTST	3,800	154 – 170	.85	51,680
48	Culture milk vat	22,900*	38 – 190	1.0	3,480,800
48	Culture milk vat	22,900*	38 – 190	1.0	3,480,800
46	Culture cream vat	11,100*	38 – 190	.90	1,518,480
46	Culture cream vat	11,100*	38 – 190	.90	1,518,480
28	Whey heater	25,000	90 – 118	1.0	700,000
101	Water heater	25,000	60 – 120	1.0	1,500,000
Maximum B.t.u. per hour required					1,480,844
10 percent for line and radiation losses					14,808,440
Maximum B.t.u. per hour					16,289,284

*Corrected for vat heating in 45 minutes.

One boiler horsepower is equivalent to the heat required to evaporate 34.5 pounds of water in one hour, or a heat requirement of 33,524 B.t.u. per hour. When converting to boiler horsepower, 35,000 B.t.u. per hour is usually used instead of 33,524.

$$\frac{16.289.284}{35,000} = 465 \text{ boiler horsepower}$$

Two 250-horsepower boilers (60, 60A) are suggested. These units may be operated at a 50-percent overload continuously, or 100-percent overload for short periods. This provides sufficient capacity for space heating in addition to requirements for product and water heating listed above.

Some incidental steam requirements are not listed in the above tabulation, such as steam for use in the laboratory and steam used for injection in the manufacture of cream cheese. These loads are insignificant when compared with vat heating and would occur when other equipment which requires steam was not in use.

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